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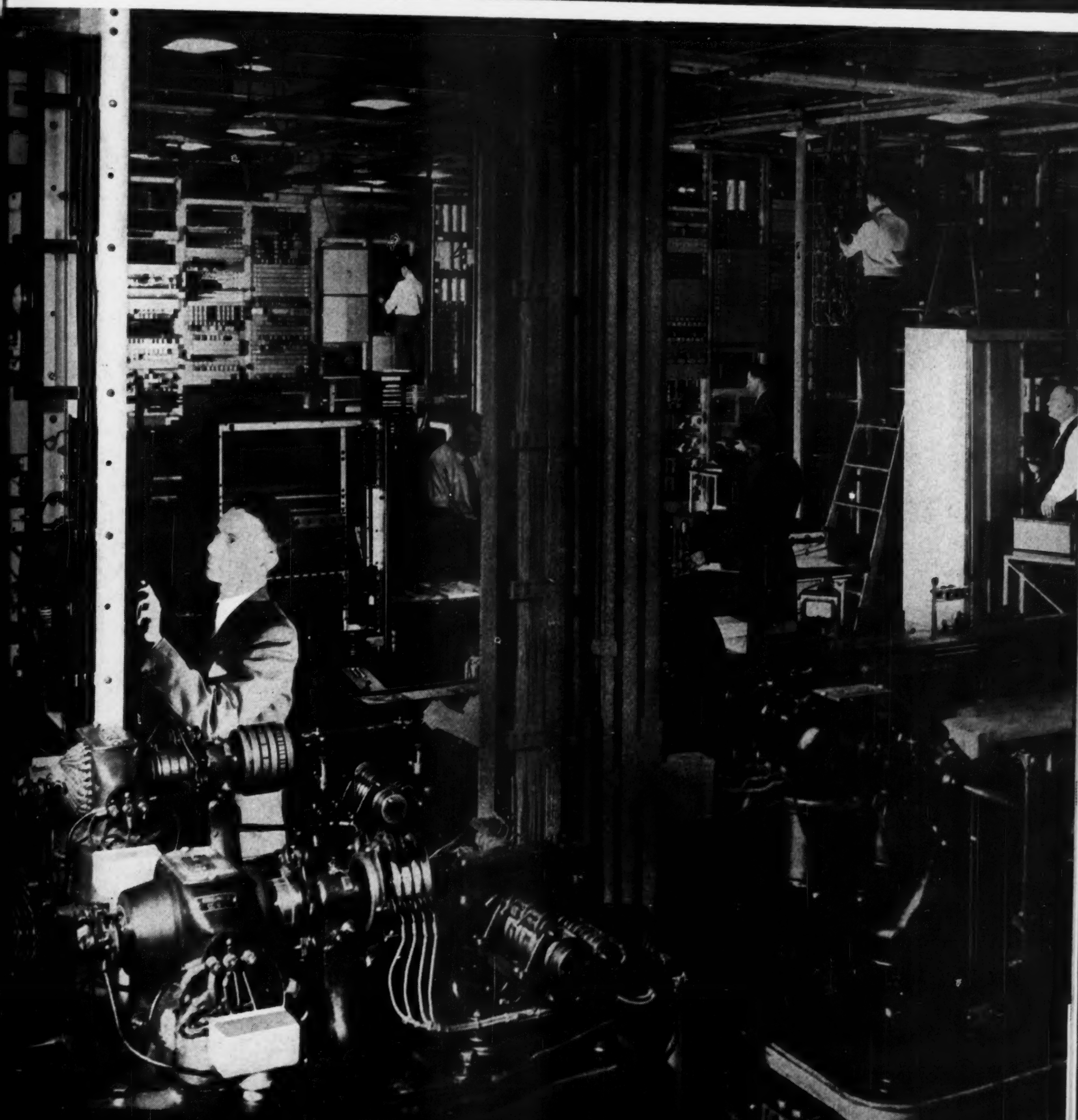

A monthly magazine for members of Bell Telephone Laboratories, for their associates in the Bell System and for others interested in the progress of the communication art.

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THE COVER

SWITCHING DEVELOPMENT LABORATORY FOR MANUAL, P.B.X., LOCAL STEP-BY-STEP AND COMMUNITY DIAL OFFICE SYSTEMS AND FOR RINGING, PULSING, RELAY AND CONTACT STUDIES

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J. M. FRASER
Transmission Engineering

THE TRANSMISSION CIRCUIT SIMULATOR

When a subscriber uses the telephone, his satisfaction with the service depends in the main upon the ease with which he carries on his conversation, or in other words, upon the grade of transmission. This has been constantly improved through the years by applying the knowledge obtained from investigations of the characteristics of speech and hearing to the design of the components of the telephone system. Whenever a new design of one of the elements of the telephone system is contemplated, the change must be evaluated in terms of its effect on transmission. Both electrical measurements and various subjective tests are made for this purpose. The latter are usually comparisons between the new and the old circuit or between the new and a reference standard circuit.

Whether or not the characteristics of some new piece of telephone apparatus will prove pleasing to the user, however,

Fig. 1—One of the multiple - listening benches in use for a test

depends not only on the apparatus itself but on the circuits and other apparatus with which it is used, and particularly with such apparatus as a telephone transmitter, on surrounding conditions in the place at which it is used. In making comparison tests, therefore, it has been necessary either to incorporate the apparatus to be tested in actual circuits in the field, or to build up equivalent circuits in the laboratories. It is generally necessary, moreover, to try apparatus with many types of circuits, and as a result considerable work has been required in building up circuits preparatory to the tests. To avoid this large amount of work for each such investigation, the Transmission Engineering Department has recently designed and built a transmission test and demonstration circuit that permits

Fig. 2—The circuit simulator panels at the rear and a terminal position in the right foreground

practically any type of circuit that will be found in the exchange area plant to be set up in a very few minutes merely by operating a few keys and changing a few plugs.

Most of the apparatus and controls for this circuit are mounted on two benches shown in Figure 2. In addition, terminal positions are required for the talkers or listeners at the two ends of the circuit. Part of one of these terminal positions is shown in the right foreground of Figure 2, while the other is in an adjacent soundproof room. Since in making a comparison, two circuits are involved, the circuit simulator permits two separate circuits to be set up. An automatic and simple means for switching from one circuit to the other is provided by a combination of pushbutton switches and relays. The two circuits are designated A and B, and the test itself is called an A-B test.

Each circuit is divided into eleven sections as indicated in the block diagram shown in Figure 3. In order, from one terminal to the other, these are: a telephone set section, representing the equipment at the subscriber's station; a loop section, representing the various types of circuit connecting the subscriber to the central office; a cord circuit section, representing the battery supply equipment at the central office; a trunk section, representing the various types of inter-office trunks; a repeating coil section, representing the various repeating coils that may connect the trunk to the toll circuits to match impedances; a toll line section, representing the various types of toll lines; and then a similar sequence in the reverse order from repeating coil to telephone set section. In each of these sections, the desired type of circuit or apparatus for both the A and B circuits may be set up merely by operating keys or inserting plugs. The input and output sides of each section are brought to terminals, and interconnecting relays — known as junction switches — may connect adjacent sections straight through or may cross-connect them so that the A part of a section may be inserted in the B circuit or vice versa. It might happen, for example, that the A and B circuits were to be alike except for a loop at one end. Under such conditions, the junction switches could be set so that the A circuit would be used for both A and B listening except for one loop section — the A side of this section being used for A listening and the B side for B listening. In this case, the two circuits would be identical except for the loop sections.

At the terminal positions, there is a green and a red lamp to indicate the A and B

circuits, and one or the other lamp lights depending on which circuit is being used at the time. These lamps are not permanently associated with each circuit, however, but may be changed from one to the other by the person directing the test. This makes it impossible for a listener to associate either lamp with either circuit. He merely notes down the color of the lamp lighted and his comments on the circuit, and since he never knows which lamp corresponds to which circuit, the possibility of his judgment's being unconsciously affected by an expected result is minimized. At each terminal there is also an attenuator which is used in some tests to permit the listener to insert loss in one circuit until he judges its performance to be equivalent to that of the other.

For the most part, the cord circuits, repeating coils, and telephone sets associated with the sections of the A-B test circuit are standard pieces of apparatus used in the plant. The trunks, loops, and toll lines, however, are built up from networks. Small steps are included so that any length can be duplicated to adequate precision. Provisions are also made for inserting filters to restrict the width of the transmitted band, which may be desirable for certain tests, and also for utilizing the master reference system* as one of the circuits. Battery supply for the cord circuits is furnished by sets of dry cells in a drawer of the benches.

In ordinary telephone conversations, noise in greater or less amount and of one form or another is almost always present. Even though the circuits themselves were perfectly quiet, there would still be room noise surrounding the listener which would have some effect on his ability to hear and understand. Noise must thus be available, controlled in volume and quality, for the A-B test. This is accomplished by recording various types of noise on phonograph records to be available for use as required. Both circuit and room noise are provided. The former is fed in controlled amounts into the circuit and the latter into the terminal rooms by use of loud speakers.

Besides its use in A-B tests as described, the transmission circuit simulator serves several other purposes. A new piece of apparatus such as a repeater may have been developed which it is desirable to test under actual plant conditions. If it were desired to test its effect on received speech, it could be placed on one of the benches, plugged into the circuit at the proper point, and subjected to an A-B test. If, on the other hand, it is desired to make physical measurements of its behavior under various circuit conditions, the necessary measuring apparatus may be connected to the circuit at points to permit almost any type of test desired to be carried out. In tests of this type, no A-B comparison is made; instead the circuit simulator provides a convenient method of connecting the apparatus to be tested into any type of circuit desired.

Still another use of the system is to

*Record, *September*, 1929, *page* 8.

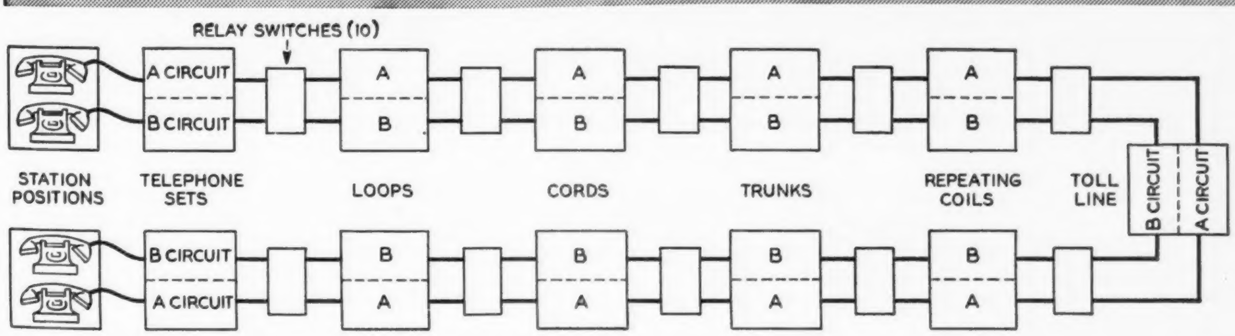


Fig. 3—*Block schematic of the circuit simulator*

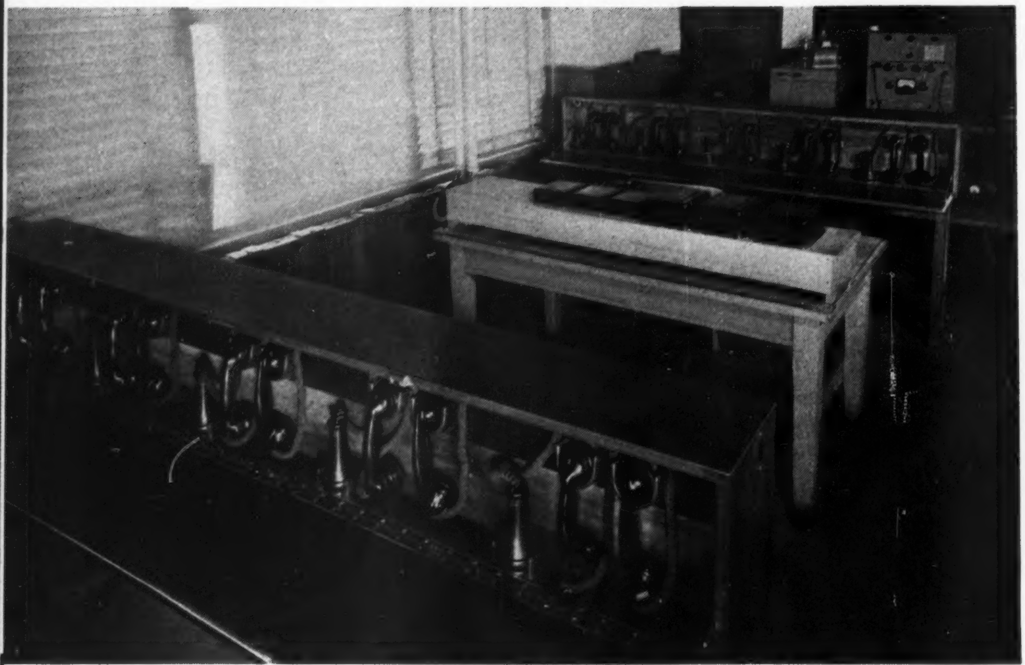


Fig. 4 — A multiple listening position is placed at each side of one of the terminal positions

demonstrate grades of transmission of various types of circuits or apparatus to individuals or groups concerned in one way or another with the telephone system. To take care of groups, multiple listening benches—one of which is shown in Figure 1—have recently been added to enable a number of people to take part in a test at the same time. Besides being helpful in giving demonstrations, these multiple listening benches have been found useful when it is desired to determine a group judgment of the transmission performance of some new piece of apparatus. Each person in a group records his own judgment, and after the results from a number of such groups have been tabulated, a dependable conclusion may be reached as to how subscribers would react to the characteristics of the particular apparatus. As shown in Figure 4, one of these listening benches is installed at each end of the room in the open space in front of the control boards. Between them is the terminal position shown in greater detail in Figure 2.

THE AUTHOR: J. M. FRASER joined the Laboratories after graduating from Brooklyn Technical High School in 1934. Beginning as a messenger, he became a Technical Assistant and then a Member of the Technical Staff. In 1945 he received the degree of B.E.E. from Polytechnic Institute of Brooklyn. He is a member of Sigma Xi, Tau Beta Pi, and Eta Kappa Nu. As a member of the transmission standards group, his work has been in the field of evaluation of subjective factors affecting the transmission performance of telephone systems. Part of this work has included the design of equipment for simulating transmission systems in the laboratory of which the "Transmission Circuit Simulator" is an example. During the war his work was chiefly concerned with the design and evaluation of secret communication systems for the Army and Navy.

A. GARDNER FOX
Radio
Research

AN ADJUSTABLE WAVEGUIDE PHASE CHANGER

Radar antennas for many applications are designed to emit radiation in a narrow beam, and the beam is swung rapidly back and forth to scan the desired area. One method is to physically wobble the whole antenna. Obviously this is mechanically an awkward thing to do, but it has been satisfactorily accomplished. Another method, although more involved electrically, avoids the mechanical problem and permits a much higher speed of scanning than would be possible by rotating the whole antenna.

This latter method is illustrated in Figure 1, which shows an antenna consisting of a number of radiating elements, with phase changers—represented by the circles—between each two radiators. For the moment it will be assumed that all the phase changers are adjusted so that when power is sent in at the middle of the array as indicated, it will divide among the radiators and jump off into space in the form of a number of individual wave components whose crests leave their radiators at the same instant. These wave crests will fuse together at a distance to form a broad flat wave front shown by the line AA. This wave will be traveling perpendicular to the line of the array in a highly directional beam.

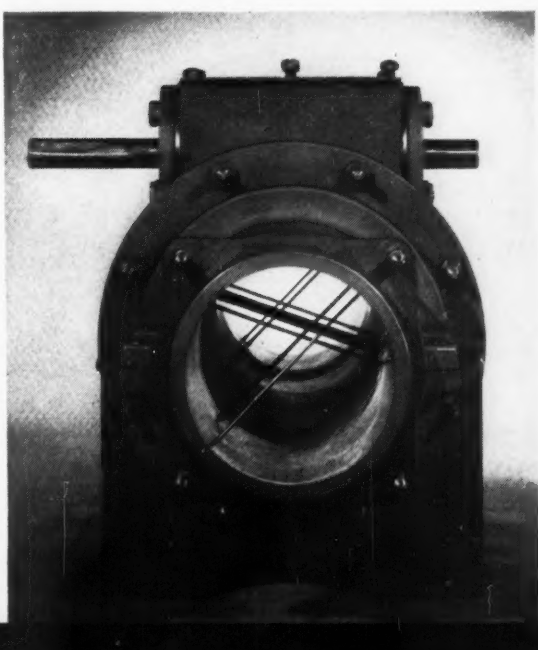
Now suppose that the phase changers are all adjusted so that each adds phase shift Θ, those to the right of the center being positive, and those to the left being negative. With such a setting of the phase changers, the individual wave crests will form a new composite plane wave-front traveling in a direction inclined to the first as indicated by the line BB. By continuously varying the phase of the phase changers, the direction of the radiated beam can be made to change continuously so as to perform the desired scanning. This principle has been used at longer waves for variable direction reception in the MUSA antenna.*

A waveguide phase changer was developed during the war that accomplishes scanning of this type in a comparatively simple manner. It consists of three short sections of interconnected circular waveguide with the middle section arranged so that it may be rotated around its axis in either direction. By rotating the middle section in one direction, the time phase of the wave leaving the changer is advanced, while by rotating it in the other direction, the phase is retarded. One of these phase changers is inserted between each pair of adjacent radiators as in Figure 1. All are rotated from a common drive at the same rate, but those to the right of the feed point are rotated in one direction, and those to the left, in the other. In this way, the radiated beam is made to scan the required area.

Many types of electromagnetic waves may be transmitted through waveguides.†

*RECORD, *January*, 1938, *page* 148.
†RECORD, *May*, 1936, *page* 283.

End view through the phase changer showing the two rods in the Δ*90-degree sections at the two ends, and three rods in the* Δ*180-degree section in the middle*



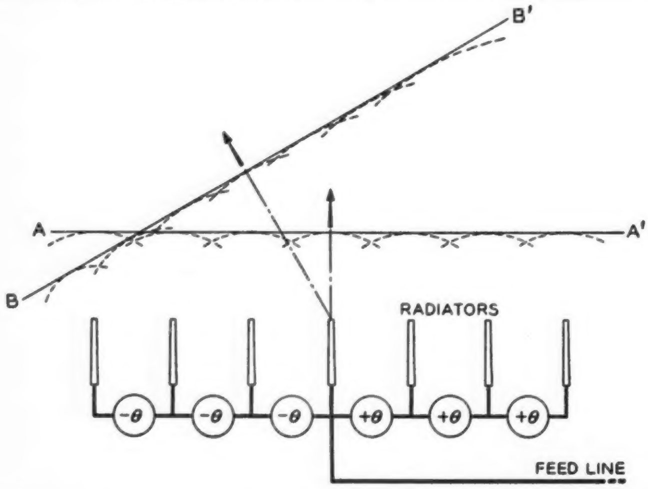


Fig. 1—An array of radiators with phase changers may be used to vary the principal direction of radiation

but for use with the phase changer, the type known as the dominant transverse electric wave is employed. Its chief distinguishing characteristic is that the electric field is transverse, and may be represented by a vector lying along a diameter of the guide. A wave of this type may be launched with its electric vector along any diameter, but once launched, its vector does not change in direction as the wave travels down the guide. Its velocity also remains constant if the guide is of uniform cross-section, but by building structures into the

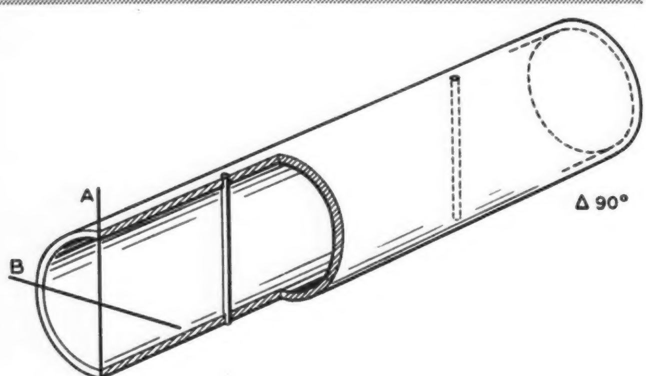


Fig. 2—Transverse conducting rod used to control velocity of wave in guide

interior of the guide, the velocity depends on the orientation of the vector.

One way of accomplishing this is to provide transverse conducting rods in the guide as indicated in Figure 2. In a guide of this type, a wave with its electric vector parallel to the rods is speeded up, while one with its vector perpendicular to them remains unaffected. A guide of this type, with two rods spaced three-eighths of a wave-length apart and properly proportioned, will increase the velocity of a wave parallel to the rods sufficiently to advance its phase 90 degrees relative to that of a wave perpendicular to the rods. If two waves, with their vectors parallel and perpendicular to the rods respectively, are started down the section with their vectors in phase at the input, they will emerge from the section with the wave that is parallel to the rods 90 degrees ahead of the wave that is perpendicular to the rods. Waveguide units of this type are called differential phase-shift sections. A section with three transverse rods can be made to give a differential phase shift between waves parallel and perpendicular to the rods of exactly 180 electrical degrees. It is by a combination of these two types of sections — for brevity referred to as Δ90-degree and Δ180-degree sections, respectively — that the continuous phase shifting required is obtained. One Δ180-degree section and two Δ90-degree sections are connected end to end with the Δ180-degree section in the middle and a Δ90-degree section at each end.

Only a single wave is passed through the phase changer, and thus at the input it may be represented by a single vector. Since any vector may be replaced for analysis by two component vectors at right angles to each other, however, the single input vector to the phase changer may be replaced by two components: one parallel to the rods, called R, and one perpendicular to them, called P. If the input vector lies along a line 45 degrees clockwise from the rods, P and R will be equal in amplitude and will be in phase. At the input to the first Δ90-degree section, assuming the rods are vertical, the two components as they

approach the phase changer could be represented as shown in line A of Figure 3. These waves are assumed to be advancing toward the right, and thus the successive values they take at the input to the section will be those encountered in following back along the line from right to left. Zero, or reference, phase is assumed to be that when P and R — and thus the single vector of which they are components — are at their maximum positive values. That P and R represent a vector fixed in space 45 degrees clockwise from the R axis may readily be seen by adding them vectorially at successive intervals from right to left. At the phase line marked zero at the bottom of the diagram, the resultant will be its maximum positive value; at the phase line 90 degrees, it will be zero; at phase line 190 degrees, it will be maximum negative, and so on, but the resultant will always lie along the line 45 degrees clockwise from the R axis, since it is the diagonal of the square that has P and R as sides.

In passing through the section, the speed of P will not be changed, and if the section is one wave-length long, it will be the same at the output as at the input. However, R will be moved 90 degrees ahead relative to P. At the output of the first Δ90-degree section, P and R would thus appear as in line B of Figure 3. Here P is exactly the same as on line A, but R has been moved 90 degrees ahead, or to the right, of its position on line A.

If P and R be now added vectorially as was done for line A, the resultant will be found to be no longer fixed in space, but rotating in a clockwise direction. On phase line zero, P is at its maximum positive value while R is zero, and thus the resultant corresponds to P and lies horizontally to the right. One quarter cycle later, represented by phase line 90 degrees, P will be zero and R at its maximum negative value. The resultant will thus be equal to R and will point vertically downward. By continuing this procedure, one will discover that the resultant is next horizontal to the left, then vertically upward, and then horizontally to the right, and thus continuously rotates in a clockwise direction.

The action of the first Δ90-degree section is thus to convert a vector that at its input is fixed in space but whose magnitude varies with time, into a vector at its output that is always of the same magnitude but rotates in a clockwise direction. While

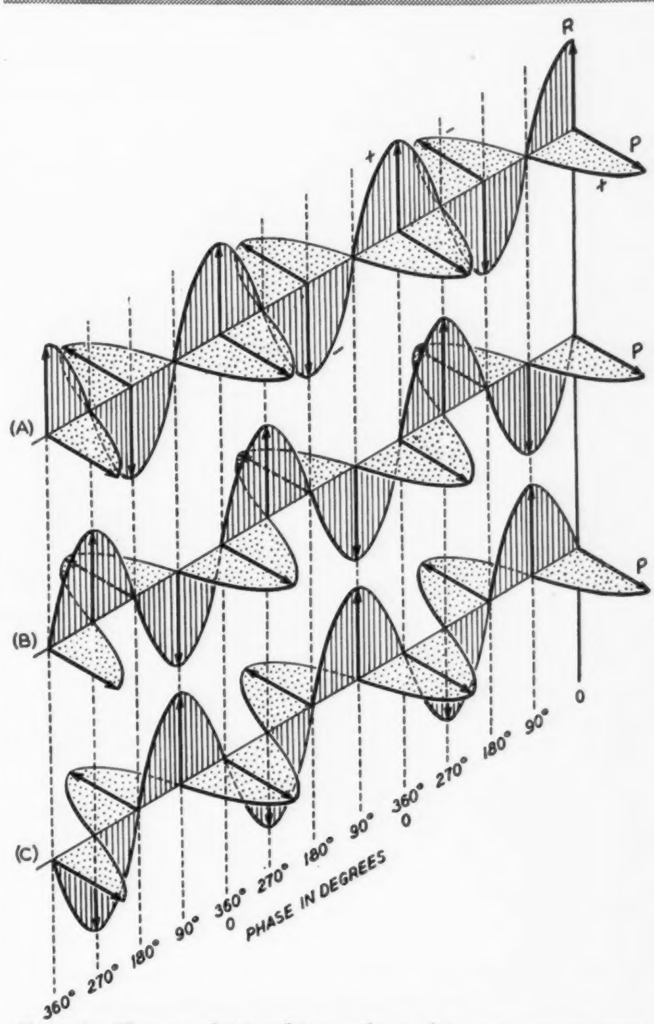


Fig. 3—Phase relationships when the two components are in time phase, on line A, when the R component is advanced 90 *degrees, on line B, and when the R component is advanced* 180 *degrees, on line C*

phase at the input corresponds to the magnitude of a vector lying along a fixed line in space, phase at the output corresponds to a direction in space of a rotating vector which is fixed in magnitude. For the condition assumed — a section one wave-length long — zero phase at the

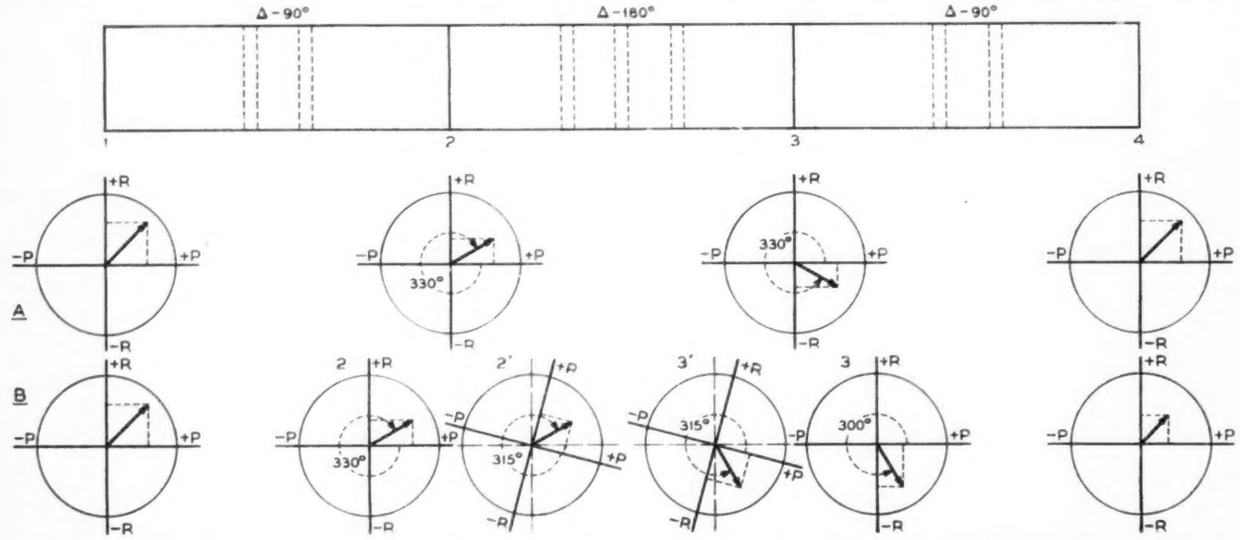


Fig. 4—Phase positions at input and output of the three sections of the phase shifter when the rods are all parallel, on A, and when the Δ180-degree section has been rotated 15 degrees clockwise, the vectors for the same input phase will be as shown on line B

output will be chosen to correspond to a direction horizontal to the right.

This clockwise rotating vector serves as the input to the Δ180-degree section, which lies next in the phase changer. If the rods of this latter section are also vertical, the resultant will be at the same angle relative to the rods on entering the Δ180-degree section as on leaving the Δ90-degree section, and thus its P and R components will be the same. In passing through this section, however, R is advanced 180 degrees. Assuming that the Δ180-degree section is also one wave-length long, the phase of P will be the same at the output of the section as at the input, and the components will appear as on line C of Figure 3. Here P is the same as on lines A and B, but R is moved 180 degrees ahead of its position on line B. If the resultant is observed at successive intervals as was done for line B, it will be found that here also it is rotating, but that it is rotating in the counter-clockwise direction. At phase zero it is horizontal to the right, at phase 90 degrees it is vertically up, at phase 180 degrees it is horizontally to the left, etc.

At the input to the final Δ90-degree section, the vector is thus rotating counter-clockwise. If the rods of this section are also vertical, it will be at the same angle with respect to the rods at the input to the final Δ90-degree section as at the output of the Δ180-degree section, and thus will have P and R components of the same value. The action of the final Δ90-degree section is to advance the R component another 90 degrees, and since it has already been advanced 270 degrees — 90 degrees in the first Δ90-degree section and 180 degrees in the Δ180-degree section — it will have advanced a total of 360 degrees and will thus again be in phase with P at the output of the final Δ90-degree section, and will again appear as on line A of Figure 3. If the final section is also one wave-length long, the phase at the output of the section will thus be exactly the same as at the input to the first Δ90-degree section when the rods of all three sections are parallel.

These conditions are shown by the four diagrams on line A of Figure 4. At the top of this diagram are represented the three phase-shift sections used in the phase changer, and the diagrams on line A directly beneath represent the positions of the vectors at the four numbered positions: the input to the first section, between the

first and second sections, between the second and third sections, and at the output of the third section. For the instant represented by the diagrams, the phase of the input vector is assumed to be 330 degrees; it is thus approaching its maximum positive value but is only about 70 per cent of it. When the rods of all sections are parallel, and each section is one wavelength long, the phase will be the same at all four positions, but while it is represented by a magnitude in diagrams 1 and 4, it is an angle in diagrams 2 and 3 – clockwise in 2 and counter-clockwise in 3.

As time passes, the vector at position 1 will extend to its maximum positive value, shrink to zero, extend to its maximum negative value, shrink to zero, and expand to its maximum positive value for each successive cycle. In step with it, the vector at 2 will rotate to the positive P axis, then to minus R axis, then to the minus P axis, then to positive R axis, and then on to the positive P axis again. During this same period, the vector at 3 will perform a similar rotation but in the opposite direction, and the vector at 4 will expand and contract exactly as the vector at position 1. At positions 1 and 4, the phase of the vector is measured by its magnitude plus or minus, while at positions 2 and 3 it is measured by the angle from positive P axis – measuring clockwise at 2 and counter-clockwise at 3.

If the Δ180-degree section were rotated on its axis, however, so that its rods were no longer parallel to those of the two Δ90-degree sections, the vector entering the Δ180-degree section would no longer be at the same angle from the positive P axis as it was on leaving the first Δ90-degree section. At position 2, therefore, one diagram is needed to show the vector relative to the Δ90-degree section and another to show it relative to the Δ180-degree section. This situation is indicated in line B of Figure 4, where the Δ180-degree section has been rotated 15 degrees in a clockwise direction, and two diagrams are used to indicate the vector relations at each of positions 2 and 3. Diagram 2 shows the vector relative to the first Δ90-degree section, and 2′, relative to the Δ180-degree section, while diagram 3′ shows it relative to the Δ180-degree section, and 3, relative to the final Δ90-degree section.

In diagram 2, the vector is at phase 330 degrees as it was at position 1. In diagram 2′, however, the phase angle is only 315 degrees because the rotation of the Δ180-degree section has moved the P axis 15 degrees clockwise from its former position. On entering the Δ180-degree section, the vector thus finds itself retarded 15 degrees in phase because of the rotation of the section. As a result of this difference in position of the vector with respect to the rods of the Δ180-degree section, the P and R components will have different values from those they had in the Δ90-degree section just left. The R component will be a little larger, and the P component, a little smaller. In the Δ90-degree section, the two components have the values shown

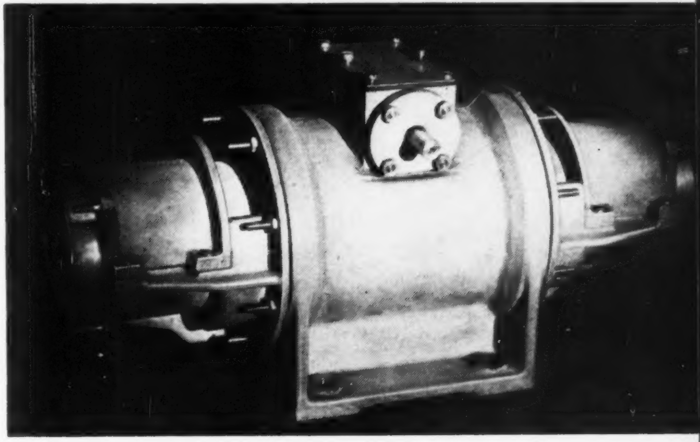


Fig. 5—The waveguide phase shifter with the drive shaft by which the Δ180-degree section is rotated

on line B of Figure 3 over the 330-degree position, while in the Δ180-degree section they have the values shown above the 315-degree position. The speeding up of the R component within the Δ180-degree section will, of course, be the same as before the section was rotated, since the effect of a section on a wave within it is not at all affected by the position of the section in space. At the output of the Δ180-degree section, therefore, the components will be as on line C of Figure 3, but moved 15 degrees to the right of the position they

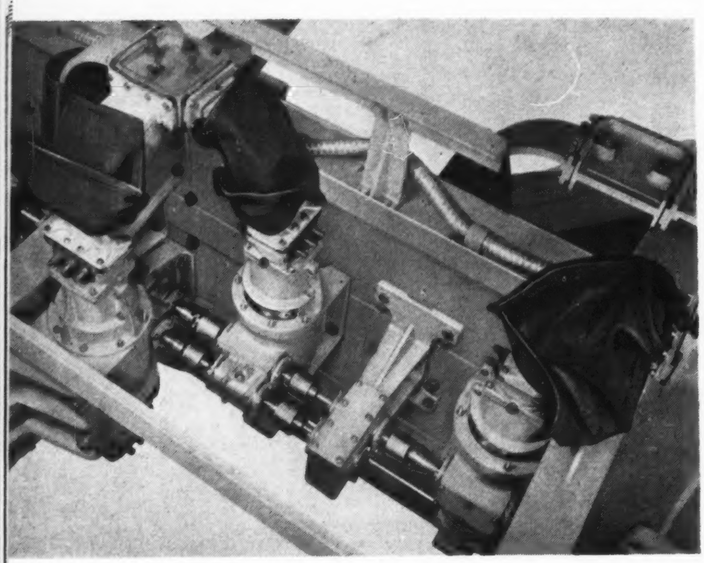


Fig. 6—A series of phase shifters connected by a common drive shaft as installed on an actual antenna

would have had if the section had not been rotated. They thus appear as in diagram 3′ of Figure 4.

Since the final Δ90-degree section has not been rotated, its P axis is 15 degrees counter-clockwise relative to that of the Δ180-degree section, and is thus 15 degrees farther from the vector than was the P axis of the Δ180-degree section. The phase angle of the vector on entering the final Δ90-degree section, diagram 3, is thus 300 degrees instead of the 315 degrees of diagram 3′. The phase, in other words, has been retarded another 15 degrees.

Since the phase at the output of a section is the same as at the input, the phase at position 4 is the same as in diagram 3, or 300 degrees. At this position, however, the phase is represented as a magnitude, and thus the vector at position 4, although approaching its maximum positive value, is only 0.5 of it instead of about 0.7 as in position 1. The 15-degree rotation of the Δ180-degree section has thus resulted in a phase retardation of two times 15 degrees, or 30 degrees. Had the rotation of the section been in the counter-clockwise direction, the output phase would have been advanced relative to the input. With the sections arranged as in Figure 4, therefore, a rotation of the Δ180-degree section by any angle causes a change in the output phase of twice that angle – lagging for clockwise rotation and leading for counter-clockwise rotation.

This method of securing the phase shift needed for scanning was used with the polyrod antenna already described.* A single phase shifter is shown in Figure 5, and an end-on view through the shifter, in the photograph at the head of this article. There, one of the Δ90-degree sections is in the foreground, the Δ180-degree section can be seen in the middle, and the other Δ90-degree section, at the far end. The middle rod of the Δ180-degree section is larger than the other two, since a Δ180-degree section is essentially two Δ90-degree sections placed end to end with the two inner rods coalesced into one.

*RECORD, *February*, 1948, *page* 64.

THE AUTHOR: A. GARDNER FOX received the B.S. degree from Massachusetts Institute of Technology in 1934, and the M.S. degree in 1935. After about a year on radio work with the General Electric Company, he joined the Technical Staff of the Laboratories in 1936. With the Specialty Products Department, he first spent two years developing mobile radio transmitters, and then transferred to Whippany to work on a radar project. A year later he transferred to Holmdel where he worked on electro-magnetic horns, waveguide filters, and other waveguide circuits, including the phase changer described in this issue of the Record. He returned to Whippany in 1942 to work on microwave design problems of the SCR-545 radars. In 1944 he again transferred to Holmdel to develop microwave amplifier circuits for radio relay systems such as that between Boston and New York. At the present time Mr. Fox is engaged in research work in the millimeter wave region.

HISTORIC FIRSTS: RECTIFIERS AS MODULATORS

Even before World War I, the Bell System was active in developing radio telephony, and as early as 1915 achieved trans-atlantic radio telephony between Paris and Arlington.* For modulation at the transmitter, the van der Bijl circuit was employed, for which a patent application had been filed that year. Although the trans-atlantic tests were successful in demonstrating the possibility of long-distance radio telephony, they also made it evident that the circuits and apparatus should be greatly improved before commercial service was attempted. The van der Bijl modulator utilized the curved relationship between the plate current and grid voltage of a vacuum tube to permit the voice wave to control the amount of amplification of a much smaller carrier wave. The envelope of the modulated wave corresponded to the voice signal, which was what was desired, but with no voice signal present, considerable plate current was passed, and thus the efficiency of modulation was not very high.

R. A. Heising, who developed the trans-atlantic transmitter and who was active in all phases of radio transmission, sought a better and more efficient modulating circuit, and in the following years proposed a number of schemes that proved valuable —notably the constant-current modulator.† In 1916, he applied for a patent that, as finally issued, disclosed two modulating schemes. One, which has been widely used, has been generally known as grid modulation. The other, although not used in the immediately following years, was the foundation of a method of modulation that has been employed in most of the modern wire-carrier systems; a method that has simplified such systems and reduced their cost, and that seems destined for even more extensive use in the future. It was modulation by rectification.

Modulation had always been conceived as the variation of the amplitude of a high-frequency carrier wave in accordance with the variations in the voice wave.

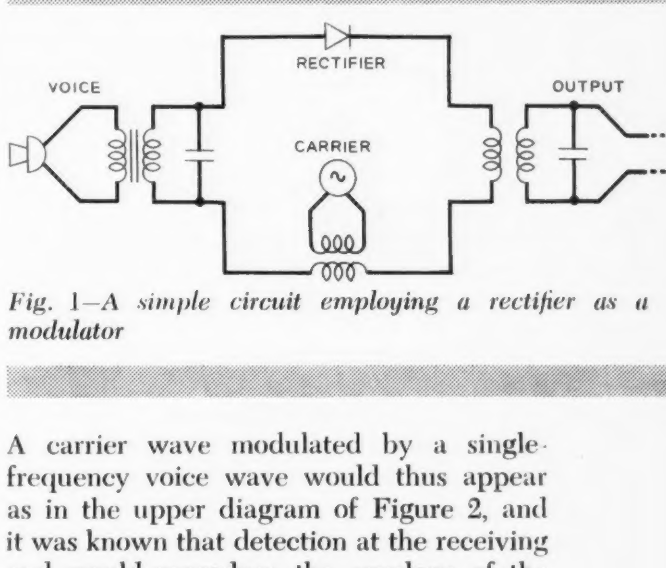


Fig. 1—A simple circuit employing a rectifier as a modulator

A carrier wave modulated by a single-frequency voice wave would thus appear as in the upper diagram of Figure 2, and it was known that detection at the receiving end would reproduce the envelope of the modulated wave, which represented the speech. Such modulation is brought about by enabling the voice waves to change the impedance of the carrier circuit in one way or another. One of the first methods was by use of the carbon transmitter. The voice waves falling on the diaphragm changed the resistance of the carbon through which the carrier is transmitted. In the van der

*Record, *September*, 1943, *page* 5.
†Record, *January*, 1945, *page* 6.

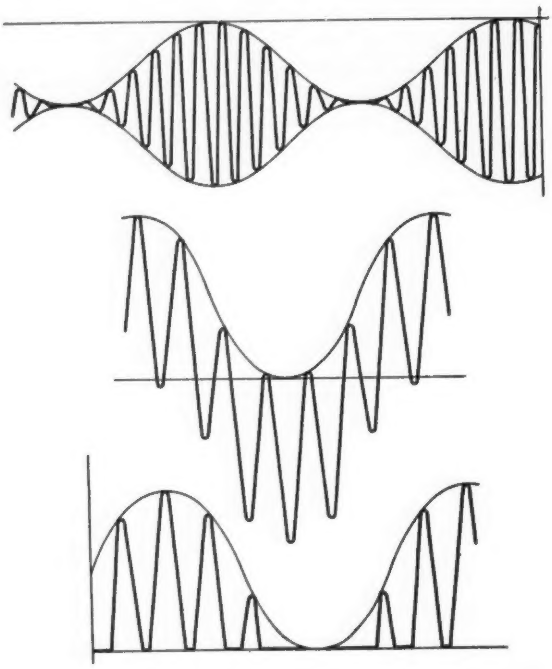


Fig. 2—Modulated wave (above) with two methods of demodulation—Heising method (center) and rectifying method (below)

Bijl system, the resistance was changed through the use of a vacuum tube, while another system employed a variable inductance. Heising's proposal was to arrange the circuit so that the voice wave would not change the amplitude of the carrier wave but would merely shift it bodily relative to the axis of zero current, thus giving a wave as shown in the middle diagram, where the amplitude of the voice wave is just equal to that of the carrier. By passing such a wave through a rectifier, which cuts off everything below the zero axis, the result would be as shown in the lower diagram. The output circuit, tuned to the carrier frequency, selects the modulated wave and thus gives a wave as shown in the upper diagram.

The advantages of this method of modulation become evident in low-power carrier systems where ample power is supplied from the carrier generator, and amplification during modulation is not necessary. A vacuum tube modulator with its power supply is thus avoided. It allows the construction of equipment having lower initial cost as well as lower maintenance and operation, and has thus found extensive use in wire carrier communication where the power is small.

This method of modulation also has economic advantages in other than very low power systems. Where several stages of modulation are involved before the resultant modulated wave or single side-band is placed in its final location, simple and inexpensive modulating elements are highly desirable. Amplification of the final wave or band can follow its placement in the frequency spectrum just as with a vacuum tube modulator.

In radio, the rectifier modulator finds little use at present. The powers involved in radio transmitters are usually considerable, and amplification after modulation would be needed. The modulator in that case affects the initial and upkeep costs to a very little extent, so that vacuum tubes have been used.

Full use of rectifier modulation has had to depend on the development of suitable rectifiers. In 1916 when this modulator was invented, the rectifiers available were electrolytic, vacuum tube, and numerous crystal rectifiers used as radio detectors, and none of these but the vacuum tube were stable enough to be satisfactory. With the improvements made in copper-oxide rectifiers during the following decade, a simpler and stabler rectifier became available, and the copper-oxide modulator,* which modulates by rectification, has been adopted for practically all broad-band carrier systems of the Bell System and for certain smaller systems as well. Modulation by rectification as proposed by Heising was thus late in coming into use, but the value of the invention—which ultimately appeared as Patent No. 1,712,993— is now fully realized.

*Record, *June*, 1945, *page* 200.

M. BROTHERTON
Publication
Department

MAKING ENERGY TALK

In talking we write words in the air; they travel to the ears of our listeners as meaningful patterns in pressure. Were a sensitive gauge held near a listening ear, the air pressure would be seen to rise and fall through a succession of hills and valleys, hundreds of times a second. Seen over a minute fraction of a second, the pattern of a word might appear as in Figure 1. Each word, each sound has its own unique pressure-pattern; this the ear drum records and the mind recognizes; and it is this pattern which all speech communication must take in, transport, and deliver.

One way to transport a voice pattern is to pack it up and send it by mail — on a phonograph disc in which the tell-tale ups and downs in air pressure have been neatly carved out in plastic by a sound recorder. In wire and radio, it is the transporting energy which has to be carved out to convey the pattern. The process of impressing the pattern on the transporting energy is known as modulation.

In ordinary speech, we modulate sound energy. Through the telephone, modulated sound becomes modulated electric current; through radio, modulated radio waves. The several methods of modulating wire and radio energy are, despite their erudite names, simple to visualize when divorced from the intricate electronic technics which put them to work, as may be seen by considering first the classical example of the everyday telephone.

The Telephone Talks With Voltage

In a telephone circuit, there exists a one-way electric tension or voltage: it remains steady so long as we are silent. As we speak, the transmitter takes in the ups and downs of air pressure and causes the erstwhile steady voltage to rise and fall in unison. In this way, the telephone circuit builds the same pattern as we started with, only now it is built in voltage instead of air pressure (Figure 2). This electrical pattern passes to the receiver, which, reversing the function of the transmitter, transforms it back into air pressure.

In every sound communication system, no matter how complicated, the very first step is always the transformation of the pressure-pattern into its electrical facsimile and the very last step is always the reconstruction of that pattern on the basis of information fed to the receiver. With more complicated systems, there is the difference

Fig. 1—Sound travels as a succession of air pressures

that the signal-bearing energy is usually carried through one or more additional processes of modulation on its way to the receiver. All of them, however, are simply different ways of signaling this self-same pattern. One example is radio wave modulation.

Talking With Radio Waves

Radio waves differ one from another in the extent or amplitude of their voltage swing, and in the rate of swing or frequency. Rendered visible, radio waves of

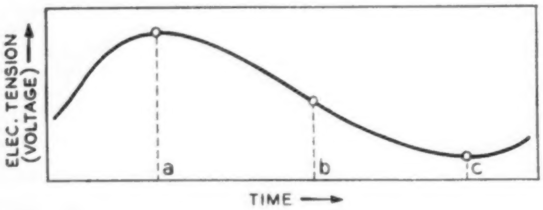


Fig. 2—Telephone circuit builds facsimile of air pressure pattern in electrical voltage

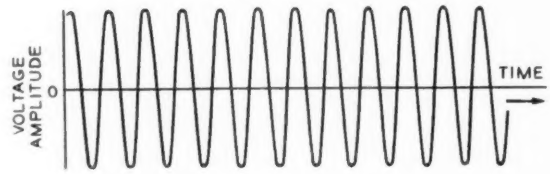


Fig. 3 – Unmodulated radio waves of constant voltage-amplitude and frequency

constant amplitude and frequency would appear as in Figure 3. Like steady air pressure or steady voltage in a telephone circuit, such unmodulated waves carry no intelligence. Waves are made to carry meaningful signals by varying either their amplitude or their frequency.

Talking in Wave-Voltage – Amplitude-Modulation

In amplitude-modulation, the voltage amplitude of the waves is made to vary so as to match, instant by instant, the pattern in Figure 2. Thus the voltage of the resulting amplitude modulated waves is lower at instant "b" than at "a", lower still at "c", and similarly in proportion for every other point (Figure 4). Thus the amplitude of the radio waves pouring as a continuous stream from the transmitter is tailored to conform to the pattern impressed. Could these amplitude-modulated waves be seen on their way through space towards the receiver, the procession of crests would present in outline an exact facsimile of the original pattern.

In interpreting amplitude-modulated waves, the receiver behaves like a voltmeter. For it measures the voltage at each instant, plots the corresponding point with respect to time and so constructs the desired pattern.

Talking in Wave-Frequency—Frequency-Modulation

In signaling with a beam of light, information may be conveyed by manipulating either the intensity of the light or its color. Amplitude-modulation corresponds to varying the intensity or amplitude; frequency-modulation corresponds to manipulating the color or frequency. For example, at

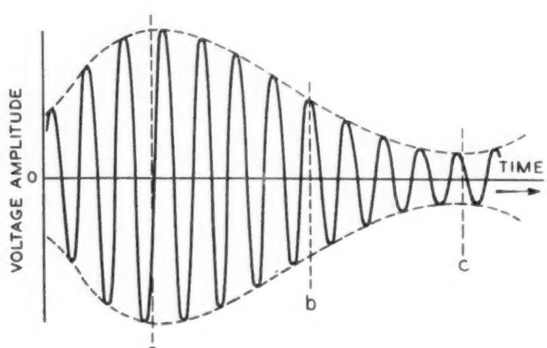


Fig. 4—The amplitude of the waves is modulated to bear the imprint of the pattern in Figure 2

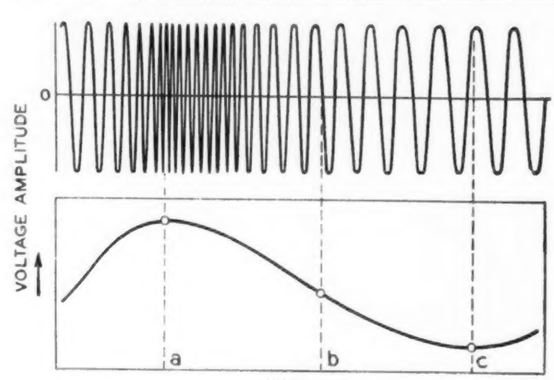


Fig. 5—Frequency-modulated waves represent the variations on the pattern by variations in frequency

instant "a" the frequency-modulated transmitter sends forth waves at a chosen frequency, at "b", waves at another frequency, and at "c" still another (Figure 5). Each and every voltage on the pattern is represented by a corresponding frequency which remains constant only while the voltage it represents remains constant.

A frequency-modulated wave-train on its way through space would appear to be constant in amplitude, but continuously varying in frequency, and its crest outline would not in any way reveal the essential voltage pattern being carried. To interpret the signals the FM receiver behaves like a frequency meter; it measures each frequency as the waves pour in, plots it with respect to time, and so reconstructs the pattern.

Talking in Samples — Pulse-Modulation

In the modulation of steady voltage in the everyday telephone as well as in the modulation of radio waves by the amplitude and frequency methods described, the pattern-building signals are transmitted in unbroken sequence so that every point is made available to the receiver for its task of reconstruction. But we do not need to know every point of a curve in order to plot it. A very few points are enough to define a simple shape like that in Figure 2, and more are needed only as the pattern becomes more complicated. This fact provides the basis for pulse-modulation.

In pulse-modulation, only samples of the pattern are sent; these samples are picked off and transmitted at periodic intervals and are sufficient in number per second to define the pattern. Each sample is transmitted as a distinctive signal — a pulse of voltage. And pulse by pulse, the receiver reconstructs the pattern. Here, exactly as in ordinary telephony, the information which is transmitted is also a voltage pattern but its contour is no longer continuous. It consists instead of a succession of rectangular bumps spaced out in time.

Pulse modulation, though usually spoken of in connection with radio, is, in itself, only another method of making energy carry meanings; it is in theory equally applicable to either wire or radio transmission, and could indeed be applied just as well to carrying voices by sound waves through the air.

Four methods whereby bumps or pulses are made into signalbearers are illustrated in Figure 6, which also shows that each

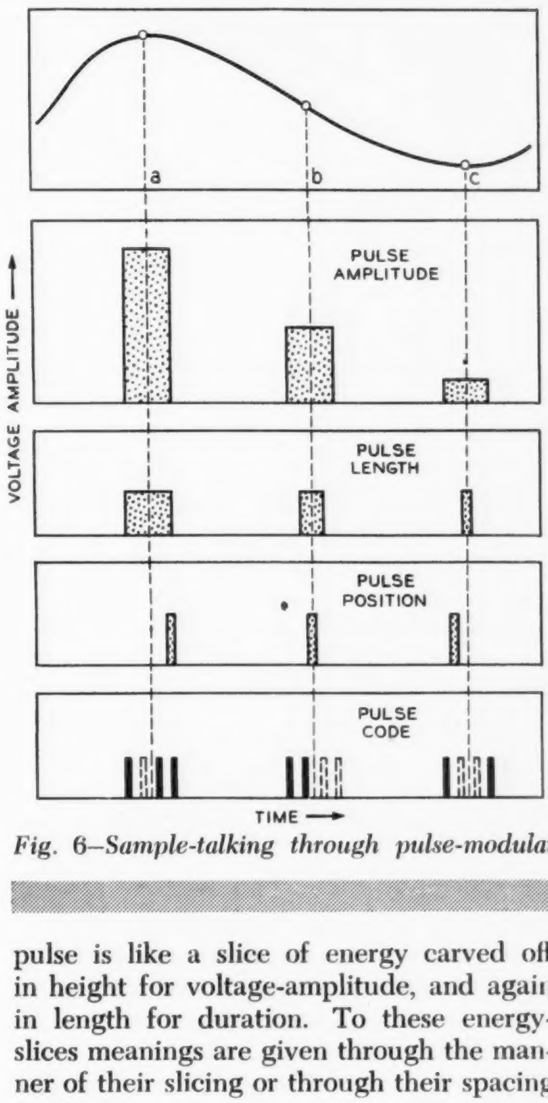


Fig. 6—Sample-talking through pulse-modulation

pulse is like a slice of energy carved off in height for voltage-amplitude, and again in length for duration. To these energy-slices meanings are given through the manner of their slicing or through their spacing in time.

Talking in Voltage Samples Through Pulse-Amplitude Modulation—I

In pulse-amplitude modulation, the transmitter sends out pulses equal in duration but unequal in voltage or amplitude; each

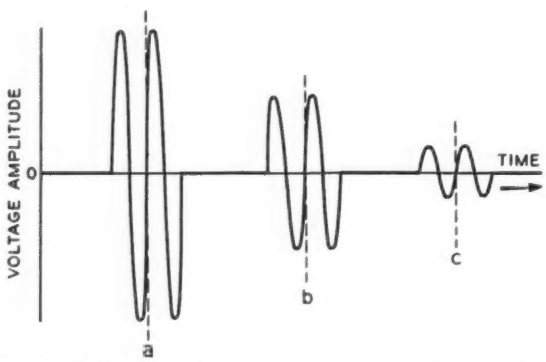


Fig. 7—Amplitude-modulated waves carrying pulses

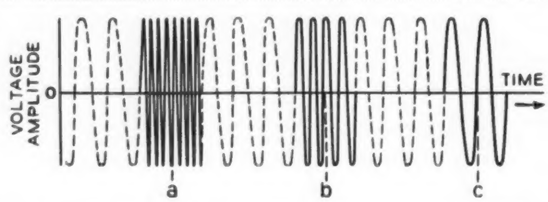


Fig. 8—Frequency-modulated waves carrying pulses

pulse depicts in its voltage a sample from the pattern. Thus, the voltage of the pulse which goes out to signify sample "b" is lower than the voltage of the pulse for sample "a", lower still for "c".

Since the significance of the pulse lies in its voltage-amplitude, the receiver must act like a voltmeter, for it measures the voltage of each pulse as it comes in and plots the corresponding point on the pattern.

Talking in Time Samples Through Pulse-Length Modulation—II

In pulse-length modulation, the transmitter sends out pulses of equal voltage, and the length (duration) of the pulse is made to vary in proportion to the amplitude of the signal; for example, the pulse which goes out for sample "b" is shorter that than for "a" and shorter still for "c".

Since the measure of the signal is now pulse duration — a time interval — the receiver must act like a stop watch. It measures the time interval from beginning to end of each pulse and plots these against time to reproduce the desired pattern.

Talking in Time Samples Through Pulse-Position Modulation—III

In pulse-position modulation, there is no difference at all between pulses in either voltage or duration: instead they differ in the time at which they are sent and received. As with railroad trains, there is a pre-arranged normal time at which each pulse is scheduled to be dispatched. Then quite deliberately the pulse is dispatched off schedule, early or late, by an interval chosen to represent the sample.

Thus for sample "a", the transmitter sends forth a pulse not at the normal time but a little later; how much later is the measure of the sample. For sample "b", the pulse leaves exactly at normal time and for "c" it leaves a significant time beforehand.

Here again the measure of the signal is a time-interval, and so the receiver again acts like a stop watch. It times the interval between the actual time of each pulse and the corresponding normal time. From the time intervals, it reconstructs the pattern.

Talking in Code Samples Through Pulse-Code Modulation—IV

In pulse-code modulation, most recent contestant in the modulation art, the pulses are not only identical in voltage and duration, but are also fixed as to the times when they may occur. The pulses are transmitted in groups, one group to each sample, and a sample is represented by leaving out one or more pulses of the group according to a prearranged code.

Figure 6 illustrates the use of a four-pulse code; here sample "a" is signaled by omitting the second pulse in the group. So the receiver's job is to note the presence or absence of pulses in the signal group and, with the aid of the code, interpret the meaning in terms of corresponding pattern-voltage.

This combination of pulse and code virtually disguises the voice pattern in transit so as to outwit that great enemy of communication: electrical disturbances, which damage electrical patterns just as room noises garble a speaker's voice. If,

however, a speaker, instead of trying to talk through room noise, were to signal the pattern to us by means of pre-arranged sequences of on-or-off gong tones, each short and sharp, our only problem would be in deciding whether or not the gong had sounded, something fairly easy to do. Pulse code modulation does just that: instead of sending the delicate pattern at the mercy of the elements, it signals the information as pulse groups able to drive through interference.

At repeater points travel-worn signals being delivered of their messages are scrapped and the pattern is launched anew to span the next lap of its journey on a brand new set of pulses. Thus clarity of transmission can be maintained through many repeaters over very great distances.

How often must a wave be sampled to secure faithful reproduction through pulse-transmission? As few as 8,000 samplings per second are sufficient to secure near-perfect reproduction of telephonic speech, but high-quality music with its more complicated pattern of more and steeper hills and valleys requires many more. Since the duration of each pulse is very brief, about one-millionth of a second, there is a long waiting interval between pulses. During this interval the pulses of many other conversations may be sent over the system.

Pulse-modulated signals cannot be transmitted efficiently over ordinary telephone circuits, since they entail high frequencies which make broad frequency-band transmission and other refinements essential. At present, pulse-modulation is being used in microwave radio where the needed frequency-space is more abundant.

In transmission by radio, the pulse-pattern may be imprinted on radio waves and transmitted through either amplitude-modulation, Figure 7, or frequency-modulation, Figure 8.

Radar

Radar is another example both of pulse-modulation and of building patterns from samples. The pulses of radio waves which a radar sends forth are similar in all respects and so do not, in themselves, convey any more information than would a buzzer sound repeated at regular intervals. Radar pulses in transit would appear as in Figure 7, except that all would be of equal height. Their purpose is to probe and sample the surrounding terrain for unseen objects. When a pulse strikes a target, that target replies with an echo. From echoes, the radar builds a picture of the target as to range, direction, and shape.

To summarize, we see that electrical energy is modulated to carry the imprint of a signal, through the manipulation of three and only three of its basic properties, amplitude, time and frequency. Each, like a special language, provides a distinctive way of making electrical energy talk.

THE AUTHOR: Following service with the British Army during Word War I, M. Brotherton attended University of London, Kings College, and was graduated in 1921. Working with Professor O. W. Richardson in thermionic research, he was awarded a doctorate in philosophy in 1924. After joining the Apparatus Development Department in 1927, he spent several years on filters and equalizers. Later he worked on capacitors and is author of a book in the Laboratories series, *Capacitors: Their Use in Electronic Circuits.* Since transferring to the Publication Department in 1943, his chief interest has been the Laboratories series of technical advertisements which appear on the inside back page of this magazine and in thirty-four others.

PLOTTING BOARD FOR 65-MC IMPEDANCE MEASUREMENTS

A. L. HOPPER
Radio
Projects

The efficient transfer of energy from one section of a circuit to another requires that their impedances be closely matched. For example, the input impedance of an amplifier must match that of the circuit leading into it. In practice, the control of this requirement calls for a speedy method of determining impedance. As an aid to measuring impedance in the 65-mc intermediate frequency circuits of the Boston-New York radio relay system, there has been devised an impedance plotting board which greatly facilitates calculations.

This method of determining impedance at very high frequencies depends on the fact that an impedance mismatch sets up standing waves in a transmission line; as a result the voltage along the line varies from point to point in conformity with the standing wave form. The standing wave voltage is a function of the impedance mismatch and the magnitude of the mismatch may therefore be calculated from three measurements of the standing wave voltage at three predetermined points.

For the radio relay system the test is made by comparing the unknown impedance with that of a 75-ohm standard consisting of the section of coaxial conductor shown in Figure 1. The unknown impedance is connected to one end of this standard; into the other end is fed a wave from a generator of known frequency. Then with a vacuum tube voltmeter the standing wave voltages are measured through the three taps which are spaced at intervals of approximately one-eighth wavelength along the transmission line.

Calculation of the unknown impedance from the observed standing wave voltages involves the solution of three equations and would be tedious and complicated were it not for the graphical chart calculator devised by P. H. Smith of the Whippany laboratory in 1939 for general use in high-frequency transmission line calculations. This chart expresses impedance in terms of the magnitude and phase of the standing wave voltages. Of these variables, the magnitudes of the voltages are known from direct measurement through the taps in the conductor and their phase relationship from the wavelength and the distance between the tap-points.

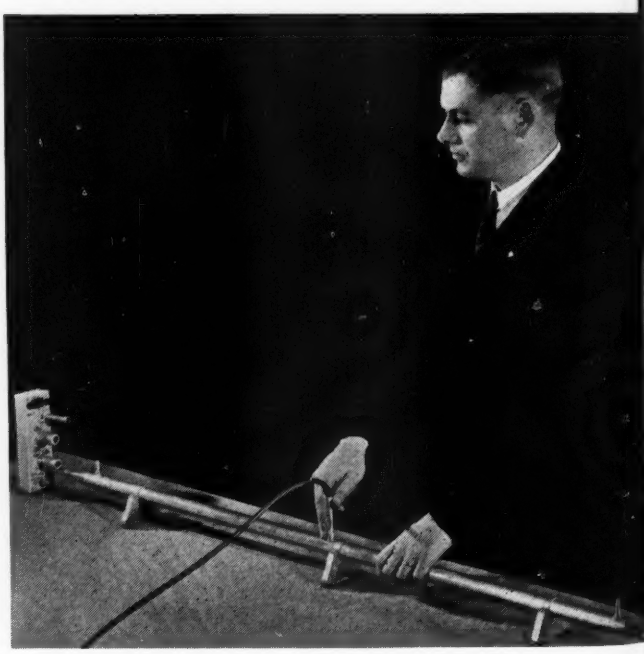


Fig. 1—J. L. Wenger attaches a coaxial lead from a vacuum tube voltmeter to one of the three voltage taps on a 75-ohm coaxial impedance standard

Essentially the graphical solution consists in drawing three arcs on the chart to represent the three voltages; then from arcs, the real and imaginary parts of the impedance may be read from the chart.

In practice, however, the three arcs do not intersect exactly at a point and much

time may be consumed in manipulating the arcs through a process of successive approximations for the desired point.

The simple plotting board shown in Figure 2 not only draws the arcs but also automatically carries through the approximation needed to determine the intersecting point.

The chart shown is a special verison of the Smith chart blown up in the ratio of 4.65 to 1 to permit impedance determinations to within ten per cent of zero mismatch.

In the use of this plotting board, each dial is rotated until it registers one of the three standing wave voltages expressed in decibels with reference to a known level. As the dial rotates it winds or unwinds the attached cord so as to move the indicator at the center. The motions contributed by the three dials maneuver the indicator to the desired point on the chart from which the impedance is read off. The angular separation between the cords represents the phase difference between the voltages.

The plotting board may be set up for different test frequencies by moving a pointer over the frequency scale at top left. This pointer controls the angular separation of the cords by moving the arms on which the dials are mounted.

As will be noted each dial controls the indicator through a double cord looped through a pulley near the dial. Starting from a common tie-point at top left, each cord passes first around a pulley

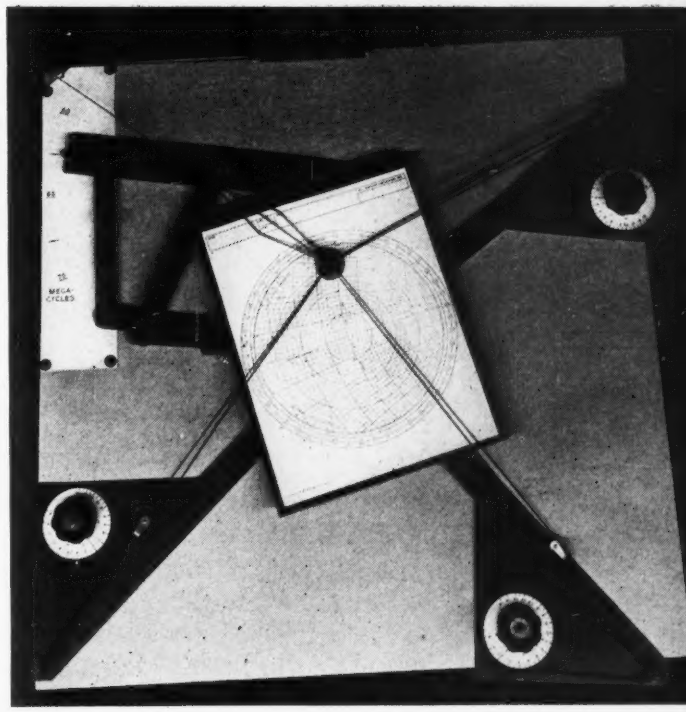


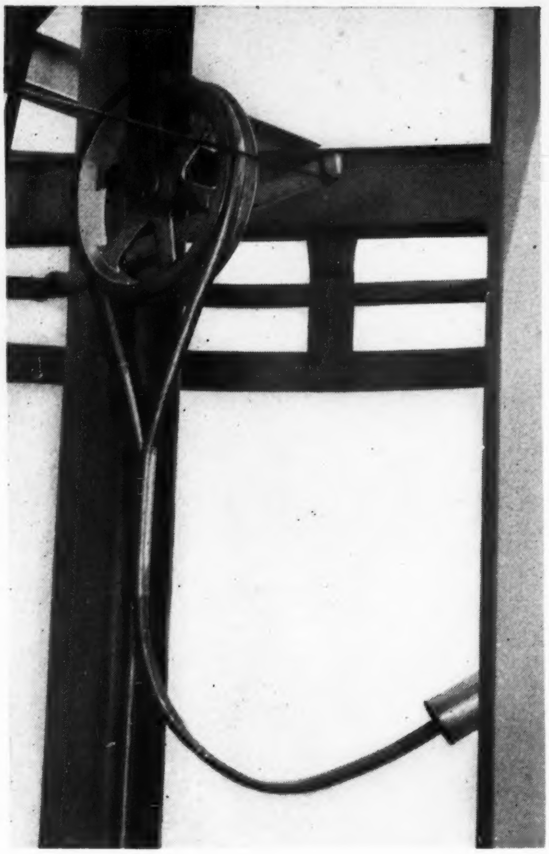
Fig. 2 — A 65-mc impedance plotting board. For clarity the three cords, upper left, are separated

in the indicator and then to the pulley near the dial whence it is looped back and tied to the indicator. As the indicator is jockeyed into position, this cord and pulley system automatically performs the successive approximations needed to fix the true point of intersection of the three arcs.

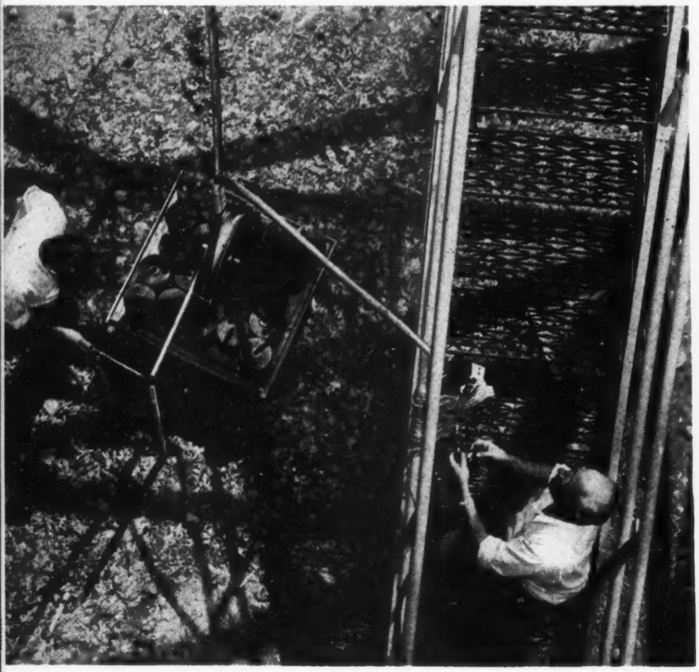
This plotting board offers a rapid and accurate means for computing impedances from standing wave detector measurements over a frequency range from 55 to 77 mc.

THE AUTHOR: Andrew L. Hopper received the E.E. degree from Rensselaer Polytechnic Institute in 1928 after which he joined the Technical Staff of the Laboratories and was assigned to the switching development group. From 1936 to 1942, he was engaged in telegraph circuit development. From 1942 to 1945 he took part in the development of proximity fuze and radar circuits. Since then he has been engaged in the design of components for the New York-Boston and New York-Chicago microwave relay systems.

TWIST AND ELONGATION TESTS OF CABLES



The microwave relay tower at Murray Hill was "borrowed" from Transmission Research by Outside Plant Development for twist and elongation tests on quadded toll cable. In the tower's shadow-pattern, below, J. H. Gray is reading the torque on the weighted and twisted cable while W. C. Sturzenegger attaches leads to the pairs for capacitance measurements being made in the adjoining terminal house. At the top of the tower, at right, above, the cable is passed over a sheave and firmly lashed to itself. The suspended length of cable is about 110 feet. This lead cable has a diameter of 1-1/2 inches and weighs 2.6 pounds per foot. The can covering the end of the cable is paper lined and filled with insulating compound to assure that the conductor ends are electrically cleared and protected against moisture. Inside the terminal house, below, F. V. Haskell (left) and an assistant measure and record the capacitances of the cable's pairs.



F. M. WIENER
Transmission
Research

EQUIPMENT FOR MEASURING SOUND PRESSURES IN THE AUDITORY CANAL

On first analysis of a telephone circuit one might be tempted to regard transmitter and receiver as the terminal instruments of the circuit. Actually, though, it is the telephone listener experiencing an auditory sensation who must be considered as the terminal; in analogy his counterpart is the speaker on the other end of the line. To evaluate overall performance of the telephone, psycho-physical test methods and procedures are necessary in order to correlate the resultant auditory sensations, for example those of loudness and pitch, with their physical stimuli. Thus listener and speaker as observers in psycho-physical tests and as users of the telephone, properly become integral parts of the telephone instrumentalities.

At the listener's end of the telephone, if one wishes to examine the performance ot a single receiver on a number of observers or investigate some of the more fundamental properties of hearing, the correlation of the physical stimulus with the auditory sensation is a basic problem. Without entering here into a discussion of what constitutes a proper measure of the auditory sensation it becomes apparent that careful consideration must also be given to the specification and measurement of the physical stimulus activating the auditory mechanism of the observer. Suitable techniques and apparatus must therefore be devised to carry out such measurements reliably and meaningfully.

Were the observer and his receiver an inseparable unit it would suffice to measure the stimulus in some convenient manner at the electrical terminals of the receiver. Since this is not the case it is desirable to determine the acoustic output of the receiver quantitatively by measuring the sound pressure at a point within the listener's auditory apparatus. By this procedure the acoustic stimulus acting on the ear may be evaluated, taking into account such variables as the receiver performance and the fit of the receiver cap to the ear. Conversely, the influence that such parameters as the receiver fit or the size of the individual auditory canal have upon the receiver performance, also can be studied.

A schematic cross section of the human ear—and, as customary, a distinction is made between the external, middle and internal ear—is shown in Figure 1. The auditory organ proper is the inner ear, more specifically the cochlea, a canal of helical form embedded in the petrous part of the temporal bone. Midway across this canal is a thin membrane, the so-called basilar membrane, along which the end organs of the auditory nerve terminate. The two canal halves thus formed are filled with liquid. They are interconnected at the far end of the cochlea by a small aperture, the helicotrema. In Figure 1 the cochlea is shown unfurled for clarity, and for simplicity no reference is made to the cochlear duct and associated organs. At the other end of the cochlea there are two apertures, one on each side of the basilar membrane. The lowermost, the round window, is closed by a membrane whereas the other, the oval window, accommodates the footplate of the stirrup, the final link in the ossicular chain. This chain, consisting of hammer, anvil and stirrup, transmits vibra-

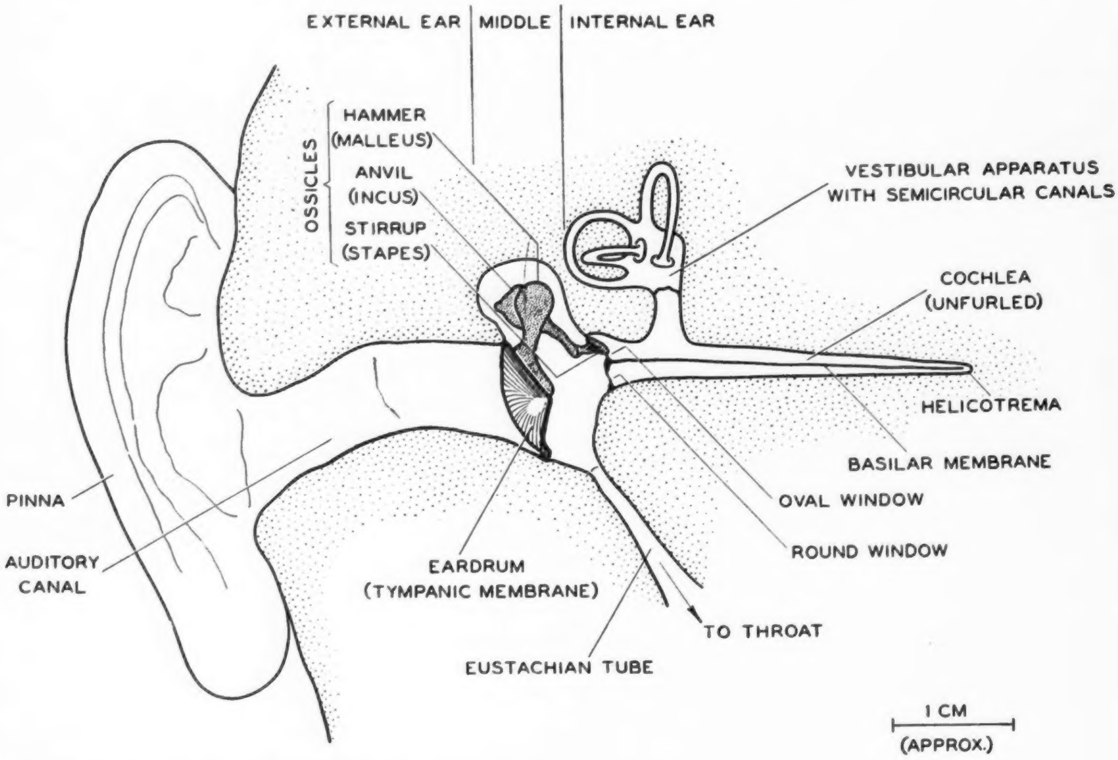


Fig. 1—Schematic cross section through the human ear

tions of the tympanic membrane to the liquid filling the cochlea. The Eustachian tube provides equalization of steady pressure between the two sides of the ear drum. The vestibular apparatus, also shown schematically in Figure 1, acts as the organ of equilibrum by utilizing the three semicircular canals which are oriented in three approximately orthogonal planes.

When the ear is exposed to sound of a given frequency the sound pressure in the auditory canal activates the eardrum whose vibrations are transmitted through the ossicles to the cochlea. Wave motion is set up in the liquid of the cochlea in such a way that the deflections on the basilar membrane are localized in a certain area. For higher frequency sound the area of maximum deflection on the basilar membrane is shifted towards the oval window and different end organs of the auditory nerve are stimulated. As the magnitude of the stimulus is increased, the deflections of the basilar membrane increase in magnitude and the stimulation of the nerve endings is increased correspondingly.

The functions of the outer ear, consisting of the pinna and the auditory canal and terminated by the eardrum, is to serve as a transducer and pressure amplifier interposed between an external sound field and the delicate and small structures of the middle and inner ear. The magnitude of the stimulus acting on the auditory apparatus can be quantitatively evaluated by a measurement of the sound pressure at some convenient point in the auditory canal.

In addition to the usual requirements imposed on apparatus for the measurement of sound pressure, a microphone to measure sound pressure in the auditory canal under a telephone receiver cap must satisfy these requirements: measure the pressure at any specified point in the auditory canal, including the vicinity of the eardrum, with-

Fig. 2—Experimental equipment for sound pressure measurements in the auditory canal, modeled by S. Balashek. A spectacle frame and headband support the microphone which is connected to the pre-amplifier on the left shoulder. The search tube is bent to enter the ear canal and the seal of the telephone receiver is not appreciably broken by the tube. Duplicate equipment is used on the right side for binaural measurements

out exposing the observer to undue hazard and discomfort; be small and light, interfering with neither the receiver seal nor the wearer's comfort; and be so designed that its introduction into the canal will not affect the pressure distribution there and the acoustic impedance presented to the telephone receiver.

Experimental equipment, which satisfies these requirements to a large extent has been designed and used in the Laboratories. Figure 2 shows the equipment mounted for the left ear and it is duplicated on the right side for binaural tests. The microphones consist essentially of a small search tube coupled to a Western Electric type 640AA condenser transmitter. The search tube is bent suitably so that it can be inserted into the auditory canal. A spectacle frame and headband are used to support the slight weight of the transmitters which are connected to their tubular pre-amplifiers by means of flexible cables. In this manner the search tube is fixed in position so that it interferes little, if at all, with the seal of the receiver against the subject's auricle. Due to its small size the equipment is equally suitable for measurements in an open sound field. This adaptability is particularly valuable for certain psychophysical measurements of the loudness-balance type where the loudness experienced by an observer exposed to the sound field of a distant source is compared with the loudness experienced when a receiver is worn. The presence of the search tube does not interfere with the process of making the loudness balance and the sound pressures in the ear canal can be measured at all times.

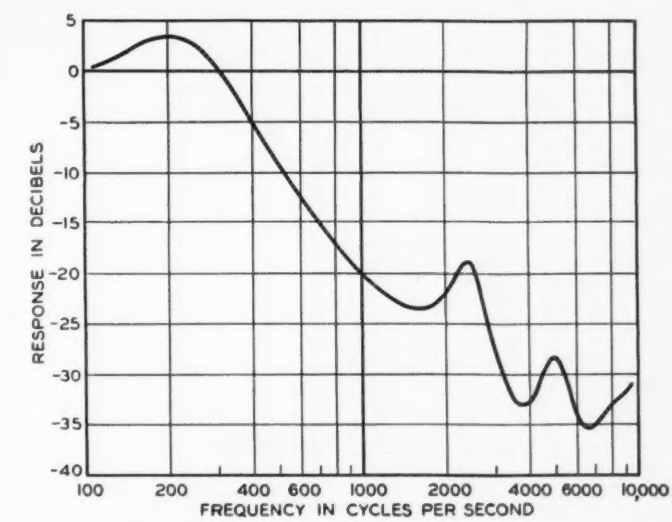
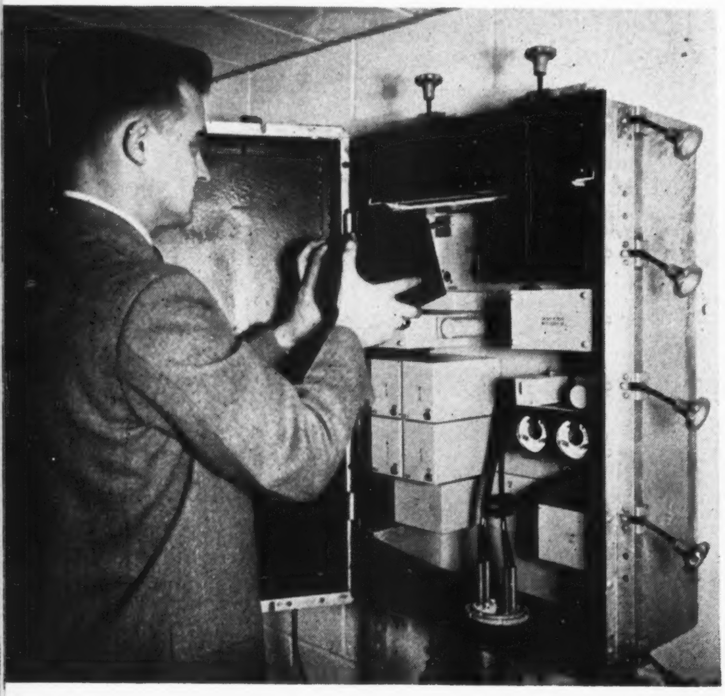


Fig. 3—Relative calibration curve of a search tube transmitter. Through use of a simple equalizing network the sensitivity may be made reasonably independent of the frequency in the range shown

A typical calibration curve of a search tube microphone of the type described above is shown in Figure 3. The sensitivity is measured in terms of the open-circuit voltage developed by the condenser transmitter for constant sound pressure at the opening of the tube. A simple equalizer may be used to make the sensitivity reasonably independent of frequency over the range of frequencies shown, except for some relatively minor resonant peaks.

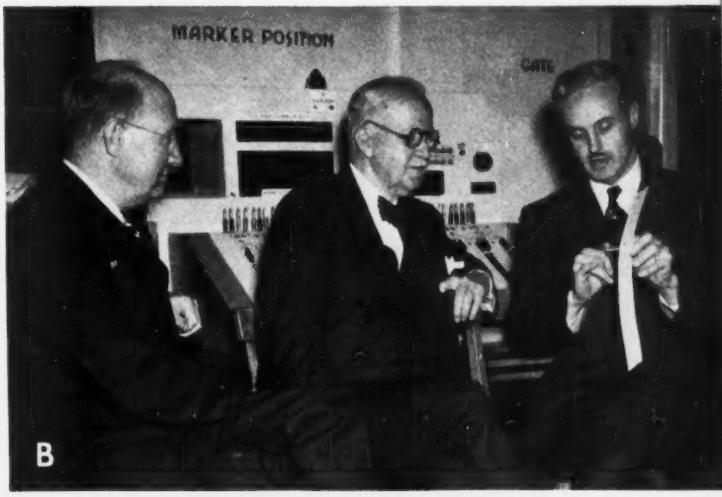
Equipment of this type has been and will continue to be extremely useful in studies of the properties of hearing and also for investigations of telephone receiver performance under conditions of actual use.

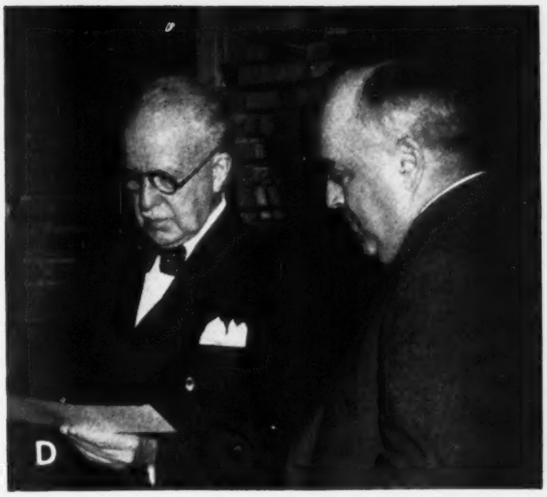
THE AUTHOR: Francis M. Wiener graduated in Electrical Engineering in Prague, Czechoslovakia, in 1934. After spending several years in industry, working on electro-acoustic devices, he resumed his academic training at Harvard University in 1938 pursuing graduate work and teaching in acoustics. He received his master's degree in 1939 and his doctorate in 1941. After a brief interlude at Stromberg-Carlson he returned to Harvard to join the staff of the Electro-Acoustic Laboratory. As Special Research Associate and senior group member he did research work in military communications and acoustics under the auspices of NDRC until 1945. He continued certain aspects of this work as Research Fellow at the Psycho-Acoustic Laboratory at Harvard for the Office of Naval Research until 1946 at which time he joined the Laboratories as a member of what is now the Transmission Research Department. Dr. Wiener's work is at present primarily concerned with psycho-acoustic tests and the fundamental aspects of hearing. He is a Fellow of the Acoustical Society of America and a member of the Society of Sigma Xi.



The New York-Albany coaxial system was placed in commercial operation on May 21. Installation of this 154-mile cable was a joint project of the New York and New Jersey Companies and Long Lines. The cable runs from New York City through the northeast corner of New Jersey and then near Southfields, Monroe, Kingston, and Catskill in New York. The cable was placed in underground conduit between New York City and Monroe and between Catskill and Albany. Between Monroe and Catskill most of the cable has been buried in the ground.

At the left, C. G. Arnold of Transmission Development is shown replacing an amplifier in this system in the unattended repeater station at Arden, N. Y.





Mr. Gifford Visits West Street

Following his address at an executive luncheon conference in the West Street Auditorium on May 13, Mr. Gifford was shown a number of new projects in the Laboratories.

A–S. B. Ingram explains the operation of a beam coding tube

B–R. I. Wilkinson tells how, in the traffic study machine, each telephone call is represented by a peg and a piece of cardboard

C–Mr. Gifford hears about one of our switching projects from John Meszar

D–H. H. Lowry explains a record from the new central office trouble recorder

E–S. F. Swiadek winds a grid for a miniature vacuum tube while Mr. Gifford, J. A. Morton and Thomas Rushetski look on

William Wilson, Former Executive, Dies

William Wilson, who at the time of his retirement in 1942 was in charge of Personnel and Publication, died on May 6 at Raleigh, North Carolina, where he was Professor of Physics at North Carolina State College. Dr. Wilson, a brother of R. H. Wilson, General Service Manager of the Laboratories, was educated at the University of Manchester and at Cambridge University where he studied radioactivity under Sir Ernest Rutherford and carried on electronic investigations under Sir J. J. Thompson. In 1912 after receiving his doctorate in science he became lecturer in physics at the University of Toronto and in 1914 joined the Research Department of the Laboratories where his background of training and research experience eminently fitted him for the work which was rapidly getting under way. In 1915, Dr. Wilson was sent to San Diego to set up a radio receiving station to listen for signals from the experimental transmitter at Arlington, Virginia. After successful completion of these tests, a program of further research was projected in which he was placed in charge of the research and development work on vacuum tube filaments. During World War I he had charge of the manufacture by Western Electric of vacuum tubes for the Government and in 1918, he became responsible for vacuum tube research, development design and manufacture. Continuing these responsibilities up to October, 1933, he was intimately associated with the development of high-vacuum tubes. In 1925 Dr. Wilson took charge of radio research activities of the Laboratories, resulting in short-wave radio telephone systems for communication with Europe and transatlantic liners and in improved ultra-short-wave systems. In 1927 he became assistant director of research; in 1934 to his duties were added the supervision of research into problems of communication by wire; he was assistant vice president in charge of personnel and publication from 1936 to his retirement in 1942.

Dr. Wilson was active in the A.I.E.E., the I.R.E.—from which he received the Medal of Honor in 1943—the A.S.A. and the American Physical Society. Shortly before his death he was elected a member of Sigma Xi. He also found time to paint, was a member of the Salmagundi Club, and did amateur dramatic work in Christ Episcopal Church, Short Hills.

Before he went to North Carolina State College, Dr. Wilson taught in the Physics Department at Phillips Exeter Academy. Last summer he visited most of the British Isles and toured Europe. Returning to Raleigh last Fall, he was hospitalized in October and again in May by the heart condition which caused his death.

William Wilson, 1887-1948

Dr. Wilson is survived by his wife, the former Ada Edlin and three sons: William, David and Stephen.

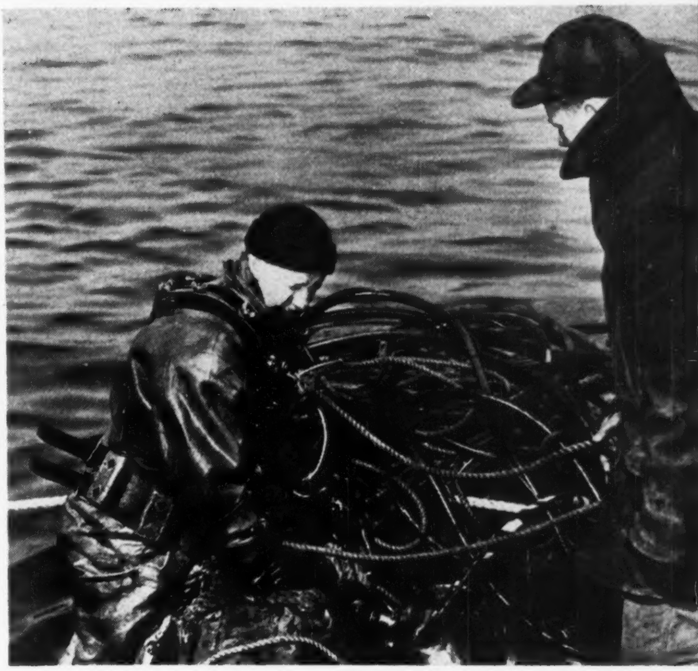
Dr. Buckley Receives Honorary Degree

Cited as a "pioneer in the development of new methods of producing high frequency power and of increasing the speed of submarine telegraphy," Dr. Buckley received on May 21 the honorary degree of Doctor of Engineering from Case Institute of Technology. In making the presentation T. K. Glennan, newly elected president of the Institute said: "Your career combines inventive genius and high administrative capacity. In grateful tribute to your services to your country in two world wars and as Director of Research and president of one of America's outstanding laboratories, we confer on you the Honorary Degree of Doctor of Engineering."

During a symposium at Case on the previous day, Dr. Buckley spoke on the future role of the engineer in world affairs. On the same day, at invitation of Randolph Eide, President of the Ohio Bell Company, Dr. Buckley attended a luncheon at which he addressed a group of their supervisory people.

Trapped by Mud, Diver Telephones for Help!

Dramatic rescue of a diver imprisoned under harbor mud for several hours had special interest to people of the Laboratories because the diver, Eddie Christiansen, was working on a telephone cable project. Main cable runs of New York Telephone toward Philadelphia and Washington cross from Bayonne to Staten Island under the Kill van Kull. To place these cables safely below a Government dredging operation, a contractor had dug a trench through the mud — and some rock — and eighteen new cables were laid in it. While final adjustments to the cables' positions were being made, one wall of the trench caved in and Christiansen was trapped. Fortunately his air and telephone lines were unharmed, and the diver calmly reported his plight to his employer aboard the tender. Another diver summoned from his work some ten miles distant, went to work with a jet hose and had Christiansen's helmet uncovered by the time two Navy divers arrived. Working in pairs, the three blasted through the mud with their heavy stream of water and in four hours the victim was freed.



Eddie Christiansen, professional diver on the Kill van Kull submarine cable replacement project. This photograph was made after a previous trouble-shooting trip to the bottom

Route of the New York-Philadelphia cables

Then Christiansen began the happiest ascent of his 20-year career. Examined on deck by two waiting doctors and found to be in good shape despite his nerve-racking experience, Eddie reached for a cigarette and answered a newspaperman's question with: "Give up diving? Of course not. I'll be back on the job tomorrow."

And he was.

E. H. Colpitts Awarded Medal for Merit

The Medal for Merit, highest civilian award, has been conferred on E. H. Colpitts, former vice-president of the Laboratories who retired in 1937. Presentation was made in Washington on April 5 by Assistant Secretary of the Navy John Nicholas Brown. The citation, signed by President Truman follows:

"To Dr. Edwin Henry Colpitts, for exceptionally meritorious conduct in the performance of outstanding services to the United States from June, 1940, to June, 1946. Dr. Colpitts, as member and Head Technical Aide of Division 6 of the National Defense Research Committee, Office of Scientific Research and Development, made a valuable contribution in the determination of the policies of the Division in the field of sub-surface warfare. He directed certain phases of the broad program having to do with the improvement and

development of echo-ranging systems and attack directors. Throughout the period of his service, Dr. Colpitts' adroit and expert advice, and effective guidance proved to be an invaluable aid to the war effort."

Dr. Martin Lectures at Local Colleges

Dr. C. E. Martin, Medical Director of the Laboratories, participated in The Institute for Occupational Health of the Long Island College of Medicine during the fifth Post-graduate course in Industrial Medicine held from April 5 to 16. On April 6 he gave a lecture on *Industrial Plant Medical Records and Statistics,* describing the Laboratories unique system of record keeping in code which has attracted wide attention because of the ease with which data may be extracted. He lectured on the same subject at Columbia University School of Public Health of the Faculty of Medicine during a Post-graduate course offered for physicians, engineers and nurses on April 29. Dr. Martin, on May 12, spoke on *The Basic Elements of Medical Service in Industry* at the Conference on Medical Administration Problems in Commerce and Industry sponsored by the Schools of Business Engineering and Public Health of Columbia University. During the annual meeting of the American Association of Industrial Physicians and Surgeons in Boston, Dr. Martin was elected to Fellowship.

Whippany Men's Glee Club

With hopes high for the future, twenty-six members of the Men's Glee Club of Whippany brought their first season to a close at a dinner and songfest, with their wives as guests, at the William Pitt restaurant in Chatham. Started last November as an unofficial "bad-weather" activity for men who liked to sing, the Club grew despite short noon-hour rehearsals and lack of piano accompaniment. Under the direction of B. J. Thomas, a group of Christmas carols, presented at Whippany, were followed in February by a second informal concert. The Glee Club also participated in a musicale at the request of the Welcome Wagon Newcomer's Club of Morristown who sponsored the venture.

West Street Exhibits Prints and Slides

The Twenty-Second Annual Photographic Print and Slide Exhibition was held during the week of May 3 in the West Street Auditorium where prints selected from eighty entered in the contest were hung and slides from 194 entered were shown during noon hour. E. Von Nostitz was print chairman, K. L. Warthman, chairman of color slides, assisted by W. S. Suydam and by E. K. Alenius, F.R.P.S., F.P.S.A., who with Lloyd Varden, F.R.P.S., and Earl Buckley, A.P.S.A., A.R.P.S., judged the Exhibition. Winners in

A CUTE TRICK — *Alexander Edwards*

LUST — *W. J. Rutter*

the Landscape and Marine class were, first prize and an honorable mention, C. A. Fischer, second, L. E. Cheesman, and third, J. F. Neil; in the Portrait class, all three prizes to W. A. Rutter; in the Child Study class, first, Alexander Edwards, second, A. J. Pascaralla, and third, J. F. Neill; and in General class, first, J. Baumfalk, second and third, W. S. Suydam, with honorable mention to J. Baumfalk and T. E. Davis.

In the slides division, with a limit of four slides per contestant, prize winners were W. J. Rutter, a portrait; J. B. Howard, view of Grand Canyon; M. M. Algor, an ice storm; J. W. Niedzwiecki, railroad train in snow; and Anna K. Marshall, Fall landscape.

We See by the Papers——

WESTWARD? NO!

OFFICIAL DENIES RUMOR OF PLAN TO MOVE BELL LABS

MURRAY HILL. – If any Bell Laboratories employees from here soon find themselves enjoying mineral baths at Colorado Springs or climbing Pikes Peak, they'll probably be doing it on their own and not company time. An official company statement last night denied widespread rumors that the Laboratories plan moving to Colorado to be safe from atomic bombs.

A Bell spokesman said the Laboratories officials "at the present time have absolutely no plans or information of plans" to move from either Murray Hill or New York. In fact, he added, the persistent rumor is now becoming a joke among employees.

The spokesman said there are also no plans to turn present buildings or those being completed over to the Veterans Administration for use as hospitals, as has been rumored. –*Newark Sunday News, May* 2, 1948.

Aid to New York State Vacationsist

A New York State Travel Bureau has been opened for the convenience of the general public by the Division of State Publicity, State Department of Commerce. The Travel Bureau, staffed by travel information experts and stocked with an assortment of free travel and vacation literature, is located in Room 904, 342 Madison Avenue, corner of 44th Street.

Anyone seeking detailed information on New York State vacation resorts is invited to visit the Travel Bureau, open daily from 9 A. M. to 5 P. M., and consult with the travel specialists. Hunting and fishing licenses are available as well as full information on all aspects of outdoor life in the Empire State such as state parks, campsites, cabins and beaches. Those unable to make the visit in person may call Murray Hill 7-2360 to receive information over the telephone or by mail.

RELENTLESS NATURE *J. F. Neill*

Stamp Clubs Meet at Murray Hill

A joint meeting of the Stamp Clubs of Murray Hill, Kearny, West Street and the A T & T was held on April 23 at Murray Hill. H. T. Webber, Murray Hill Chairman, greeted the fifty-one philatelists in the Arnold Auditorium, where they examined philatelic exhibits and then visited the new acoustic "dead" room under the guidance of J. R. Erickson. Later, with A. J. Akehurst as auctioneer, they bid for sixty-six lots of philatelic material submitted by various members of the Club.

There's an Orchestra Now at Murray Hill

Music at Murray Hill has taken a new trend. During noon-hour almost any day, one may hear small groups of strings, woodwinds, or brass rehearsing in Arnold Auditorium. Reason for the increased musical activity is the newly formed Murray Hill Symphony Orchestra

sponsored by Bell Laboratories Club and directed by P. B. Oncley. Though not large, the orchestra has a fairly well balanced instrumentation and expects to add to its membership after the new buildings open at Murray Hill. Rehearsals have been held regularly through the Spring months and plans have already been made for next season.

Thirty Engineers Go to Allentown

To facilitate the design and manufacture of electronic devices at the Allentown, Pennsylvania, plant of Western Electric, thirty Laboratories engineers are now resident at that location. Twelve trucks, most of them 32-foot trailers, were required to move the 97 tons of office, shop machinery and laboratory test equipment from Building T and 395 Hudson Street. A. I. Crawford of Electronic Apparatus Development, engineer in charge of the move, is shown in the photograph on the left labeling cases while C. F. Loomis of the Plant Department, move coordinator, is shown at the right.

News Notes

O. E. Buckley addressed the National War College in Washington on methods and types of equipment in communications and discussed forthcoming advances in the art.

M. J. Kelly presented a paper *Science and Military Preparedness* on April 5 at the Symposium on Underseas Warfare conducted by the National Research Council's Committee on Undersea Warfare in Washington. At Atlanta on April 15, Dr. Kelly addressed a group of supervisors of the Southern Bell Telephone Company, and on the following

During the Months of January, February and March the United States Patent Office Issued Patents on Application Filed by the Following Members of the Laboratories

H. M. Bascom (2)	T. L. Dimon	W. Y. Lang	H. G. Och	D. H. Ring
A. C. Beck	J. O. Edson	C. A. Lovell	R. S. Ohl	F. F. Romanow
R. Black	H. Fletcher	J. B. Maggio	B. M. Oliver (2)	H. C. Rorden
D. C. Bomberger	A. G. Fox (3)	J. M. Manley	B. Ostendorf	S. A. Schelkunoff
W. L. Bond	W. D. Goodale	W. A. Marrison	R. L. Peek (2)	W. M. Sharplee (2)
R. Bown	W. R. Harry	W. P. Mason (6)	E. Peterson	A. M. Skellett
L. J. Bowne	P. L. Hartman (2)	R. F. Massonneau	W. G. Pfann	P. T. Sproul
W. H. Brattain	W. H. T. Holden	B. McKim	J. R. Pierce	K. D. Swartzel (2)
H. B. Briggs	F. A. Hubbard	W. McMahon	T. J. Pope	D. E. Trucksess
E. T. Burton	K. G. Jansky	L. A. Meacham	R. K. Potter (2)	B. T. Weber
C. C. Cutler	A. E. Joel	G. W. Meszaros	D. A. Quarles	G. W. Willard
A. M. Curtis	J. B. Johnson (3)	S. E. Miller	W. T. Rea	S. B. Williams
S. Darlington	R. W. Ketchledge	J. A. Morton (2)	C. D. Richard	A. V. Wurmser
J. Davidson	E. Lakatos	J. F. Muller		

day he spoke before the faculty and members of the Business Adminstration School student body at Emory University, Georgia. He also visited the Institutes of Nuclear Studies and Metals at the University of Chicago and the Western Electric plant at Hawthorne.

H. W. Bode, R. W. Hamming, L. A. MacColl, B. McMillan, J. W. Tukey and O. J. Zobel attended meetings of the American Mathematical Society on April 16 and 17 at Columbia University, at which Mr. McMillan presented a paper, *Realizibility of Passive Networks—Preliminary Report.*

J. R. Haynes attended a conference on *Fundamental Properties of the Electric Arc* at Johns Hopkins University.

which he was appointed to the Committee on Publications of that society.

R. M. Bozorth participated in a meeting of the A.I.E.E. Basic Sciences Sub-committee on Magnetics in Pittsburgh before he sailed on the S. S. *Washington* for Great Britain and several countries on the continent.

At the Washington meeting of the American Physical Society, held from April 29 to May 1, papers were presented by Charles Kittel, *Theory of the Ferromagnetism of Simple Tetragonal Arrays;* W. H. Hewitt, Jr., *Microwave Resonance Absorption in Ferromagnetic Semi-Conductors;* and H. Christensen and C. J. Calbick, *Sintering Process Study by Electron Micrography.* K. K. Darrow presided over a *Symposium on Radiofrequency and Microwave Spectroscopy* and outlined the topics under discussion. At this symposium Dr. Kittel discussed *Microwave Resonance Absorption in Ferromagnetic Materials.* W. Shockley presided over the session on *Solid State Physics Including Semi-Conductors.*

Celebrating Marguerite Johnston's service anniversary and the thirtieth anniversary of the 4A Files are these girls, clockwise, Carolyn Jones, Anne Schifferstein, Audrey Miller, Anne Muchler, Miss Johnson, Adela Wojtaszek, Dorothy Thompson, Mildred Lanzetta and Frances Kaufmann. Many members and former members of the Files returned for the dinner, some coming from as far away as Delaware and Pennsylvania

Harvey Fletcher attended a symposium of the National Research Council's Committee on Undersea Warfare held on April 5 and 6 in Washington. He was also present in that city for meetings of the National Research Council Committee on Hearing; the Acoustical Society of America, during which he presided over the *Psychoacoustics* session; the National Academy of Sciences; and the American Physical Society.

K. K. Darrow spoke on *Magnetic Resonance* at Oak Ridge during a meeting of the Southeastern Section of the American Physical Society; and in New York before the New York Section of the American Institute of Electrical Engineers. Dr. Darrow attended a Council meeting and the general meetings of the American Philosophical Society during

Elizabeth Wood, G. C. Danielson, W. L. Bond, B. T. Matthias and A. N. Holden attended the joint meeting at New Haven of the American Society for X-ray and Electron Diffraction and the Crystallographic Society. Papers were presented by Mr. Holden, *Crystal Growing,* and by Mr. Matthias, *Ferro-electric Activities of Barium Titanate.* Mr. Matthias also spoke before the Physics Colloquium at the University of Chicago.

Legion Forms Visiting Committee for Veterans Hospital

Western Electric Post No. 497, American Legion, sponsored a program of songs and dances presented to patients at the Veterans Administration Hospital, Manhattan Beach, on Friday, May 7. Arrangements were made by H. S. Hopkins of the Laboratories.

The Western Electric Post, which includes members from the Laboratories as well as other Bell System companies in New York, is participating in the volunteer aid program at the Manhattan Beach hospital, providing volunteer aid details two nights each month. Duties of these details include all forms of assistance to patients — from providing entertainment and visiting to ward duties, dispensing of nourishment and moving patients to and from scheduled entertainment. Plans for summer activities include several parties in which the Post will play host to groups of patients at ball games and other outings.

Tossing out the first softball at Whippany, O. M. Glunt opened the season for one of the most popular sports at that location

Members of the Laboratories participating in the program are C. H. Dalm, E. J. Flannery, H. S. Hopkins, R. L. Newby, R. G. Schuster, L. W. Stammerjohn and E. G. Strubing.

Vacation Pay Advances

Before going on vacation, some members of the Laboratories like to draw pay in advance. Arrangements for doing this have recently been revised so that individuals may fill out a request form and forward it directly to Payroll, at least 11 (calendar) days before departure, Approval by a supervisor is needed. Split vacations require separate requests. Blanks have been distributed desk-to-desk; additional blanks are in stockrooms.

You can draw all the money that is coming to you, but before you spend it all, remember you'll be at work a week (at least) before you draw another pay.

News Notes

Carl Whitmore, president of the New York Telephone Company, is the new President of the Telephone Pioneers of America. Mr. Whitmore, elected by mail balloting to serve during the year beginning July 1, succeeds Joe E. Harrell, president of the New England Telephone and Telegraph Company.

R. K. Honaman spoke on *Microwaves for Your Telephone* in Peoria on April 29 before the Illinois Telephone Association and on April 30 at Bradley University before the Illinois Valley Section of the A.I.E.E. Mr. Honaman also spoke on the same subject in Decatur on May 3 before the Illinois Society of Engineers and at the Decatur High School. In the demonstrations he was assisted by J. W. Pollio.

L. H. Germer presented a paper, co-authored by F. E. Hayworth, *A Low-Voltage Discharge Between Very Close Electrodes*, at Johns Hopkins University, Baltimore.

R. C. Newhouse and R. F. Lane were in Washington on naval aircraft radio.

J. E. Karlin, violinist, assisted by D. P. Ling, accompanist, gave a half-hour program on April 29 at noon in the Arnold Auditorium, before an appreciative audience.

K. G. Compton inspected wood preservative specimens at the Laboratories test plot at Gulfport and visited the Southern Bell Telephone offices in Miami, Atlanta and New Orleans in connection with finishes on vehicles and outside plant hardware.

M. D. Rigterink discussed problems connected with the manufacture of ceramic capacitors at the American Lava Corporation, Chattanooga, Tennessee. Mr. Rigterink, J. R. Fisher and A. W. Treptow attended the 50th anniversary annual meeting in Chicago of the American Ceramic Society. At Hawthorne they conferred on ceramic material and processing.

A. H. Hearn, with members of the Chesapeake and Potomac Telephone Companies of Baltimore City and Virginia, inspected southern pine poles in the vicinities of Frederick, Maryland, and Richmond to check the preservative merits of certain types of cresote.

R. H. Colley and G. Q. Lumsden were among those attending the annual meeting of the American Wood-Preservers' Association held in St. Paul, Minnesota. They also visited the Forest Products Laboratory at Madison, Wisconsin, to study the progress of wood preservative tests.

A. P. Jahn visited test sites of the American Society for Testing Materials at Bridgeport Sandy Hook, State College and Pittsburgh to inspect, with the subcommittee of which he is chairman, the coated steel wire undergoing atmospheric corrosion tests.

G. T. Kohman and W. F. Janssen visited the Stetson Ceramic Company in Chicago for discussions on ceramic insulators. Mr. Kohman attended American Chemical Society meetings there and then went to Cleveland to the Brush Development Company to discuss the growing of crystals.

C. V. Wahl assisted in setting up and operating new rolling mills at the Naval Ordnance Laboratory in Washington.

A. C. Walker participated in a conference on textile heating and drying at the Institute for Textile Technology, Charlottesville, Virginia. At the University of Virginia, he discussed properties of single crystals with Professor Gwathmey. Dr. Walker presented the motion picture *Crystal While You Wait* at Simmons College, Boston, and at Rutgers.

U. B. Thomas, H. V. Wadlow and L. A. Leatherman made tests on a nickel cadmium battery installation in the Yale University PBX at New Haven.

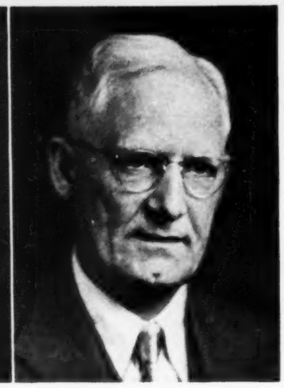
W. E. Campbell and F. Hardy went to Buffalo for the annual meeting of the American Society of Lubricating Engineers.

R. D. Heidenreich visited the NACA Laboratories at Langley Field to discuss the electron microscopy of light metals. Mr. Heidenreich was appointed to a committee on the electron microscopy of steels at a meeting in Pittsburgh.

Typical of the Laboratories self-service stockrooms is the Murray Hill Chemical Stockroom, where all types of acids, solvents and the various kinds of chemicals and glassware, used primarily by the Chemical Laboratories, are maintained on open shelves to facilitate their withdrawal by chemists. Storekeeper T. J. Prendergast, who is shown at his desk was talking to F. H. Winslow, rear, and N. R. Pape and Frances Burbank were making selections from stock when Cameraman Jorgenson took the picture

RETIREMENTS





Jacob Weber H. W. Everitt H. T. Reeve

Members of the Laboratories who retired on May 31 were Jacob Weber with 46 years of service; H. W. Everitt, 39 years; and H. T. Reeve, 30 years.

Herbert W. Everitt

Mr. Everitt graduated from Pratt Institute in 1908 and a year later joined the Inspection Department of the Western Electric Company. Later he transferred to the Shop Physical Laboratory and in 1912 he took charge of its activities in the design and construction of testing equipment for shop inspection.

When the Shop moved to Hawthorne the following year, Mr. Everitt transferred to the Research Department, taking part in the early development of the vacuum tube under Van der Bijl, in the Arlington-to-Paris radio telephone experiments in 1915, and in subsequent drafting and design work on radio equipment. When the Radio Research Department was formed, he took charge of organizing the service groups for it, and on the incorporation of the Laboratories three years later he engaged in installation surveys for public address systems. The following year he joined the Commercial Relations Department as a specialist in the commercial phases of vacuum tubes, and in 1928 he became supervisor of the case service work of that department. In January, 1948, Mr. Everitt was made Assistant to the Commercial Relations Manager and since last September has been a member of the Job Evaluation Committee, analyzing and evaluating clerical jobs.

Howard T. Reeve

Mr. Reeve, Metallurgist, received his B.S. in Metallurgy degree from Birmingham Univeristy, England, in 1909. For the next three years he was with the National Physical Laboratory in Teddington, England, and then came to this country. Before joining the Laboratories in 1918, he had been with the American Optical Company in Southbridge, Massachusetts.

In his thirty years of service in the Laboratories, Mr. Reeve has made many important contributions in the technique for handling and processing precious and base metals for contact purposes, vacuum-tube filaments, light-valve ribbons and magnetic tapes. Of particular importance has been his work in the drawing of fine wire and in "duplexing" precious metals to base metals for central-office switching apparatus and other equipment by the inlay, overlay and edgelay processes to get the most use out of the precious metal at a minimum cost. He has also been responsible for designing special equipment for doing this work among which are rolling mills, wire-drawing machines, slitting machines and vacuum pouring apparatus for melting contact and filament materials.

Jacob Weber

Mr. Weber of the General Service Department worked on polishing and buffing of telephone apparatus in New York until 1913 and in Hawthorne until 1918 when he transferred to the store room for desk stand parts. In 1920 he returned to West Street and worked as a receiving clerk in the Receiving Department. Since 1928, in the same department, he has been responsible for deliveries of material throughout the building.

News Notes

H. W. Hermance visited central offices in Chicago to confer on studies of panel commutator maintenance and to obtain further information on the effects of dusts on contact performance. He also was in Pittsburgh regarding contact maintenance in panel offices. With T. F. Egan and G. H. Downes he observed environmental factors affecting crossbar switching at the Kenmore central office in Cleveland.

V. T. Wallder conferred on plastic insulated wire and cable at Point Breeze and Hawthorne. He has been appointed a member of the A.S.T.M. Subcommittee on *Methods of Aging Vinyl Compounds.*

L. A. Wooten, J. J. Lander, N. B. Hannay and J. A. Burton attended the M.I.T. Physical Electronics Conference at Cambridge.

C. S. Fuller attended the American Chemical Society meeting in Chicago where he presented a paper on *Contributions of Polymer Chemistry to the Paint, Varnish and Plastics Industries* as a guest speaker of the Plastics Division. J. B. Howard, H. W. Hermance, D. A. McLean and G. N. Vacca attended the meetings. Mr. Vacca also attended the Division of Rubber Chemistry sessions.

C. L. Semmelman investigated trial installations of signaling filters at Richmond, Virginia.

A. G. Ganz conferred in Haverhill on general transformer and magnetic materials problems; and D. W. Grant and H. E. Vaiden, on cost reduction features in audio transformers.

Charles Kittel's Letter to the Editor, *The Physical Review,* April 1, 1948, was entitled *Domain Theory and the Dependence of the Coercive Force of Fine Ferromagnetic Powders on Particle Size.*

B. M. Oliver spoke on *Band Width Power and Noise Considerations* on April 8 and L. A. Meacham, *Pulse Code Modulation* on May 6, during a course in Pulse Modulation Systems and Techniques given in the Engineering Societies Building and sponsored jointly by the Communication Division, New York Section of the A.I.E.E. and the New York Section of the I.R.E.

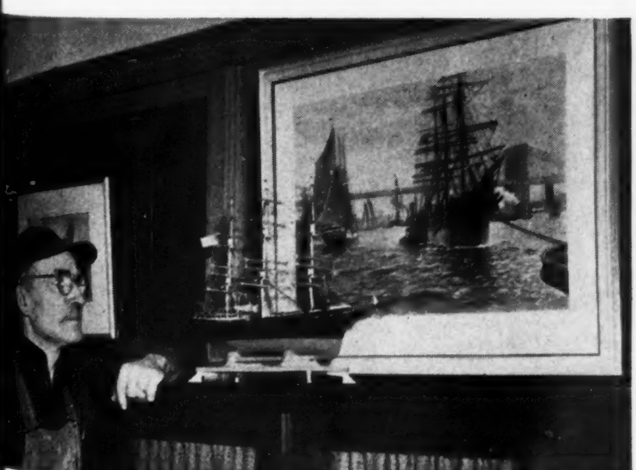
W. A. Marrison gave a talk on *Modern Methods of Precise Time Measurement* before the Cornell Chapter of Sigma Xi at Ithaca. On April 30, Mr. Marrison attended the American Physical Society meeting at Washington.

K. G. Coutlee attended the American Ceramic Society convention in Chicago and a meeting of the A.S.T.M. committee on glass. He also visited Hawthorne to discuss insulating materials.

W. J. King visited the Boston Insulated Wire and Cable Company, Boston, regarding the development of special cables.

At the Western Electric Company in Chicago, H. A. Frederick, J. J. Kuhn and D. H. Gleason discussed new crossbar switches; H. O. Siegmund, B. F. Runyon and W. G. Laskey, wire spring relays, message registers and precious metal contacts; J. B. Howard, polymer developments; D. A. McLean, capacitor materials; A. J. Christopher, paper condensers; T. H. Guettich, the design of new multi-contact relays and molded wire line relays; W. G. Turnbull, molding problems of station handsets; J. E. Greene and R. L. Lunsford, crossbar developments; P. W. Sheatsley, equipment development problems concerning the No. 1 crossbar; and E. I. Green, F. J. Given, E. B. Wood and R. O. Grisdale, switchboard lamps, condensers and resistors, and with W. L. Casper, N. Insley and R. A. Sykes, they visited Allentown to discuss switchboard lamps and crystals.

When John E. Johnson, a carpenter in the Plant Department, was called upon to hang a picture in P. B. Findley's office, he remarked that he had made his first trip around the Horn as a cabin boy in a ship similar to the model shown



Collating in the Mimeograph Department is now done by this machine which coordinates as many as ten pages at a time. Isabel Polantino, supervisor, watches some of the first production as it comes from the collating machine operated by Virginia Wallard

For the sweet tooth at West Street, Anest Sakrides, left, and Polo Grafal bake fifteen layer cakes a day, some seventy pies (half of them apple), hundreds of sweet buns, in addition to dozens of cup cakes and muffins, puddings, gelatine desserts and baked apples, and special cakes and cookies for conference luncheons

R. F. Glore supervised the field trial installation of Teflon separators at the accounting center in Philadelphia.

P. B. Drake was in Philadelphia in connection with automatic message accounting projects.

J. D. Tebo assisted in setting up the subcommittee on magnetics of the A.I.E.E. Committee on Basic Sciences in Pittsburgh.

R. C. Kamphausen, M. Salzer, and F. M. Pearsall, Jr. serviced the new KS-13834 perforator preparatory to load tests about to be started at the Media office.

C. N. Hickman, who was an associate of the late Dr. R. H. Goddard in the development of rockets for use in World War I, was a guest at the unveiling of the first public display of Dr. Goddard's basic rocket designs at the Museum of Natural History, New York. The exhibit, which will be on display for about three months, is sponsored by the Guggenheim Foundation and will be moved to other principal cities throughout the country and eventually deposited for safe-keeping in the proposed Aeronautic Museum of the Smithsonian Institution, Washington.

W. H. Doherty spoke on European trip before the Engineers Club of Greensboro and the Rotary Club of Winston-Salem.

W. C. Tinus spoke before the Armed Forces Staff College at Norfolk.

G. N. Vacca visited several rubber laboratories in Akron to discuss accelerated aging of rubber and allied products.

J. H. Waddell has been appointed Chairman of the newly formed High Speed Motion Picture Committee of the S.M.P.E.

Dr. Joel H. Hildebrand, Dean of the College of Letters and Science of the University of California, spoke in the Arnold Auditorium on *Order and Disorder Among Molecules* during a visit to the Murray Hill Laboratories in April.

King Kamehameha's Telephone

From Hawaii comes the picture below of attractive Betty Rapoza of Mutual Telephone, and one of that company's first telephone receivers said to have been used by King Kamehameha. This telephone was built by California Electrical Works under license from Western Union. Another specimen is in our Museum.

Hawaii's first telephones were ordered in 1878 from the mainland by Charles H. Dickey, local merchant. Now there are nearly 70,000 telephones on three islands interconnected with each other and the mainland by radio. When Betty hears a subscriber ask for "Seven Puka Puka Five Puka" she connects to 70050, according to Long Lines Magazine. "Puka" means "hole" in Hawaii's pidgin english; hence, "zero".

June Service Anniversaries of Members of the Laboratories

40 years	Thomas Solan	F. B. Monell, Jr.	P. B. Drake	F. I. Smith
S. J. Guss	*25 years*	Anna Muller	Ludwig Evers	H. W. Straub
W. C. Kiesel	H. G. Arlt	G. C. Porter	W. D. Goodale, Jr.	E. E. Thomas
35 years	A. L. Bonner	G. V. Ryan	C. B. Green	W. C. Tinus
R. C. Mathes	F. A. Brooks	G. C. Southworth	Reginald Knutsen	R. A. Vanderlippe
30 years	H. D. Cahill	Mildred Thuebel	A. S. Martins	*15 years*
W. J. Adams, Jr.	Cornelius Coakley	Wiley Whitney	Mauro Mianulli	R. W. Lange
W. L. Daly	T. H. Crabtree	*20 years*	Otto Mohr	E. C. Wintermantel
C. D. Davidson	W. J. Distler	E. A. Bescher	C. D. Ownes	*10 years*
Marion Haggerty	J. R. Hefele	K. C. Billson	N. R. Pape	H. S. Arnold
J. F. Kearns	J. E. Johnson	C. O. Brosch	S. E. Reed	D. E. Bilton
A. C. Keller	George Jonassen	A. A. Burgess	W. E. Reichle	G. E. Hadley
A. R. Kemp	J. P. Larson	R. C. Carrigan	Annette Richter	D. B. Parkinson
J. M. Melick	F. B. Llewellyn	R. A. Devereux	G. J. Schaible	A. A. Waraske
Mildred Molloy	H. A. Miloche	E. J. Donohue	W. W. Schormann	
			L. O. Schott	

J. F. Wentz and E. T. Mottram conferred with Wright Field representatives on airborne equipment. Mr. Wentz also attended a Signal Corps conference on antennas at Camp Evans.

W. H. C. Higgins and R. R. Hough visited the Westinghouse Electric Corporation in Baltimore on a military project.

D. C. Bomberger, in New York, spoke on *Close Support Plotting Boards and Their Tactical Use* before a group of 150 bombardiers of the Mitchell Air Force Reserve Training Detail.

J. H. Cook visited the National Carbon Company in New York on military matters.

H. T. Budenbom, W. L. Mraz and J. F. P. Martin attended a conference at the Evans Signal Laboratory in Red Bank.

W. L. Filmer, with L. D. Chipman of Winston-Salem, discussed coil construction matters at the R.C.A. plant in Camden.

R. H. Ricker conferred at the Philco Coporation, Philadelphia, on various problems relating to mobile radio equipment.

H. A. Baxter spent several weeks at Chincoteague, Virginia, preparing and conducting flight tests with the Navy.

J. W. Smith attended a National Research Council meeting in Washington.

C. R. Taft went to the Portsmouth, New Hampshire, Navy Yard and to Washington regarding new submarine equipment.

J. McLay and J. E. Corbin assisted in making a trial installation of navigational radar on the steamship *John T. Hutchinson.*

M. Whitehead visited Corning (N. Y.) Glass Works to discuss adjustable glass condensers.

J. H. Waddell selected *High Speed Photography Engineering* for his talk on May 21 before the Deal-Holmdel Colloquim.

J. F. Wentz spoke at Morristown before members of the 155th Composite Squadron Air Force Reserve.

At Winston-Salem, E. W. Holm and H. A. Stone discussed pulsing networks; G. F. J. Tyne and J. J. Scanlon, special Army projects; C. T. Grant, single-sideband radio filters; C. C. Houtz, ceramic condensers; and F. B. Monell and W. E. Kahl, various filter and network problems. Others who were recently at that plant include F. E. DeMotte, F. A. Goss, R. L. Mattingly, J. R. Logie, W. A. Funda and R. F. Armeit. Mr. Houtz also visited the American Lava Corporation, Chattanooga, for discussions on ceramic materials for ceramic condensers, and Mr. Monell and Mr. Kahl participated in a conference with the Haverhill people along with the Winston-Salem people to discuss for future production the applicability of testing methods which had been used at Winston-Salem on type-N filters.

Iden Kerney returned from a week in Staunton, Virginia, where he assisted in testing an inductive communication system to be installed on trains of the Chesapeake and Ohio to provide telephone service to passengers.

H. S. Enger
1880-1948

G. H. Rockwood
1902-1948

RECENT DEATHS

Halvar S. Enger, May 12

Mr. Enger, who was retired in 1946 after twenty-eight years of service, joined the Western Electric Company at 195 Broadway in 1918 and three years later joined the Systems Development Department in the trial installation group at West Street. Transferring to the Commercial Relations Department as an analyzer for shop jobs, he handled certain commercial phases of such equipments as picture-transmission equipment, sound-picture recorders and reproducers, the Musa and announcing systems for naval vessels. During World War II, Mr. Enger was concerned with the coordination of model production on various Army and Navy projects and the maintaining of contacts necessary to insure job progress.

George H. Rockwood, April 23

Mr. Rockwood was on a personal leave of absence to teach at the University of Illinois. After receiving his B.S. degree from Dartmouth in 1924, he spent three years in the cooperative course at Massachusetts Institute of Technology from which he received his S.M. degree in 1927. He then joined the Development Department at Hawthorne and two years later transferred to the Laboratories Research Department where he engaged in researches on electron tubes, particularly development work on gas tubes of the mercury vapor, thyratron and cold cathode types. He was particularly concerned with their application to telephone systems. Early in the war, Mr. Rockwood worked on various phases of gas tubes for military application and later transferred to Whippany to work on radar. Returning to the Electronic Apparatus Development Department in Building T, he was responsible for the group concerned with final gas tube design for Western Electric manufacture. In January, 1947, he was granted a leave and became associate professor and later a professor of electrical engineering at the University of Illinois.

News Notes

H. B. Noyes made crosstalk and allied measurements on a type-J carrier line in Louisiana and on a cable containing coxials and pairs in Jacksonville, Florida.

D. T. Osgood visited Vinita, Oklahoma, in connection with tests on M1 carrier system. This system was the subject if an address by Mr. Osgood before the Minnesota Section of the A.I.E.E. in Minneapolis.

J. P. Hoffmann visited St. Louis to make temperature studies of telegraph equipment.

L. R. Schreiner inspected the 17-C toll test board at Philadelphia in respect to voice-frequency testing arrangements.

L. Pedersen went to Watertown and Milwaukee, Wisconsin, in connection with the installation of the first pole-mounted repeater cabinet for the N1 carrier system.

H. F. Loeffler of the Wisconsin Telephone Company has been visiting the Bell Laboratories for two weeks in connection with the Wisconsin N1 carrier trial.

At Point Breeze, W. L. Tuffnell and C. A. Webber discussed cords for the new combined set; and G. E. Bailey, equipment problems of new toll switchboards.

J. R. Power discussed various problems concerned with the hard of hearing at the Naval Hospital in Philadelphia.

M. S. Hawley, in Washington, attended an American Standards Association meeting of the Subcommittee B on Fundamental Sound Measurements.

C. T. Molloy and J. R. Power went to Washington where they attended a meeting of the Accoustical Society.

J. R. Brady, H. A. Lewis and P. T. Sproul inspected the television control center being installed in the Race Street building in Philadelphia for the Long Lines Department. This will serve as the focal point where television programs, originating from the national political conventions which start in June, are connected to the New York-Washington-Richmond-Boston intercity coaxial and radio network.

The Laboratories were represented in interference proceedings at the Patent Office by R. C. Terry before the Primary Examiner.

Anna Menig participated in the PBX Chief Operators Service Assembly on May 5 at the New York Telephone Company. Following talks by PBX and toll authorities, the eighty chief operators from the larger banks, business concerns, hotels and government agencies attended a luncheon at 140 West Street.

C. Shafer, Jr., and T. C. Henneberger studied exchange plant maintenance at Birmingham, Alabama.

H. M. Pruden and T. W. Thatcher spent a week at Richmond, Virginia, in connection with a new mobile signaling system.

Depicting new developments in telephony, *Telephone Screen Review* (*No.* 3) has been released to Bell companies by the A T & T. In newsreel style, the film describes microwave radio-telephony, showing the Barnstable-Nantucket system; telephone service for passengers on speeding trains; and "Paper Talk," a Bell Telephone Laboratories demonstration of artificial speech.

L. H. Allen and P. B. Fairlamb, with representatives of A T & T, the Chesapeake and Potomac Telephone Company and the Civil Aeronautics Authority, visited the National Airport at Washington to inspect communication facilities associated with new Flight Progress Frames employed by the Civil Aeronautics Association.

"Bell Labs? Follow that man with the brief case and when his hat blows off, you're there!"

"The Telephone Hour"

NBC, Monday Nights, 9: p.m.

June 21	*Jascha Heifetz*
June 14	*William Kappell*
June 28	*Ezio Pinza*
July 5	*John Charles Thomas*
July 12	*Chloe Elmo*

H. E. Ives is author of a paper in the April *Journal of the Optical Society of America*, entitled *The Behavior of an Interferometer in a Gravitational Field. II—Application to a Planetary Orbit.*

At Burlington, L. Vieth and T. H. Crabtree discussed hearing aids and their components; F. S. Corso and A. Glazer, sound instruments; Mr. Corso and T. H. Crabtree, hearing aids; E. H. Jones, standardization problems; H. F. Hopkins and L. Vieth, loudspeaker production problems. Mr. Hopkins also discussed loudspeakers with the Hawley Products and Jensen Radio Manufacturing Companies in Chicago.

V. T. Callahan observed paralleling tests of engine sets at one of the K carrier stations near Stamford. He also discussed voltage regulator problems with the General Motors Diesel engineers at Detroit.

F. V. Haskell and H. D. Breiner made a series of measurements on the Philadelphia-Harrisburg buried cable in the vicinity of Lancaster, Pennsylvania.

J. B. Dixon studied problems in production of rust-resistant steel wire at Monessen, Pennsylvania.

B. H. Klyce, J. F. Morrison, H. A. Reise and C. A. Warren attended a Radio Manufacturer's Association television meeting at the R.C.A. Laboratories at Princeton.

R. H. Ross conferred on dynamotor problems at the Eicor Company in Chicago and small motor designs at the Barber Coleman Company at Rockford, Illinois.

H. H. Felder, W. W. Fritschi, A. A. Hansen, J. C. McCoy and N. A. Newell spent a few days at Richmond in connection with toll line dialing over type-C carrier telephone facilities.

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Easy on the eyes of magazine cover gazers, but, if she lets Old Sol look too long, she'll be sorry

Sun-Days Are Here

DR. M. H. MANSON
Medical Director, A T & T

"Sol est remediorum maximum."

Those classical words — meaning "the sun is the greatest healer," in case you've forgotten your Latin — were written by Pliny the Elder early in the Christian era, indicating that even in ancient times the sun was recognized as an effective aid to good health. Now, with an eye toward summer vacations, let's talk about Old Man Sunshine and what he can do for us.

The sun is extremely valuable in maintaining good general health. One of the important benefits of outdoor recreation is sunshine. Wise exposure to sunlight improves the skin, results in desirable nutritive changes and enriches the blood. It gives one a sense of warmth and well-being, often helpful in dispelling mental depression.

The sun does this in part through its ultraviolet rays which, acting upon substances in plant life and in the skin, form Vitamin D, popularly referred to as the Sunshine Vitamin.

But Old Sol, one of Nature's greatest healers, can be a menace, too. Beyond definite limits, excessive amounts of sunlight are injurious, with sunburn the most common injury. The ultra-violet rays, unfortunately, cannot be felt while they are reaching the skin; that's why it is so easy to get an overdose of them. The rays reach the skin not only directly from the sun, but by reflection from water, beaches and desert. To a limited extent they penetrate clouds; stretching out on a cloudy day can result in a "sky-shine" burn as severe as any received on a sunny day.

These burns are just like any received from hot water, steam or other sources familiar to us. They can make a person very ill, and in extreme cases, cause death.

The best way to avoid sunburn, and still get the sun's benefits, is to take your tan on the instalment plan, increasing your sunning time gradually from 15 to 20 minutes on the first day — preferably in late afternoon — to longer periods as your skin darkens.

News Notes

D. S. MYERS and G. A. BENSON investigated wiring problems at the new No. 4 toll switching office in Chicago.

A. KENNER and W. J. RUTTER visited Baltimore regarding the first installation of a No. 3 toll switchboard.

W. L. BOND spoke on *The Electro-Optic Effect in Crystals,* and G. W. WILLARD on *High-Intensity Ultrasonic Radiation* at a conference on the work of the mechanics and solid state research groups held in the Arnold Auditorium.

H. PETERS, at an A.S.T.M. meeting in Washington, discussed hard rubber testing.

J. P. MESSANA, at the Bureau of Standards, discussed the calibration of illumination standards used with switchboard lamps.

G. H. LOVELL was at Lawrenceville in connection with tests on a filter for use in a high power radio transmitter.

B. A. KINGSBURY attended the meeting of the Metropolitan Section of American Physical Society at Brookhaven National Laboratory, Long Island.

The "sound jurors" serving in the advertisement on the opposite page are, clockwise: Irene Riley, D. F. Seacord, Florence Makoske, V. Subrizi, Christine Scanlan, J. M. Fraser, Grace Fismer, Alberta Strimaitis, E. C. Thompson, and W. J. Kopp. Lower picture shows E. C. Borman with J. M. Fraser whose article on "The Transmission Circuit Simulator" appears on page 241.

BELL LABORATORIES

RECORD